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DUFFIN
ON
STRABISMUS

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Frontispiece.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Drawn from Nature on Stone by W. BAGG.

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PRACTICAL REMARKS

ON

The New Operation

FOR THE CURE OF

STRABISMUS OR SQUINTING.

Illustrated with Lithographic Engravings.

BY

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PREFACE.

THE substance of the following pages was published a short time ago, as a series of separate communications, in the weekly medical journals*, and entitled "An Inquiry into some of the Consequences, and Causes of occasional failure, attending the new operation for the cure of Strabismus."

Considerable daily experience having enabled me, since the appearance of my first essays, to confirm, or correct, my earlier views respecting the nature of this affection, and to enlarge my original observations by the addition of numerous practical facts, I now venture to publish the whole in an independent and more connected form.

That there may be still much to amend, or to verify, more especially in the theoretical part of the subject, it would be presumptuous to deny; but, as all inquiry into the functions of the orbital muscles has hitherto baffled the acumen of our greatest physiologists, it may surely be pardoned me if any speculations in which I have indulged should be found unequal to stand the test of severe criticism.

Should there, then, appear any thing inconclusive or chimerical in the arguments adduced to explain certain of the various untoward results

* The Lancet and Medical Gazette.

that occasionally supervene when the tendon of the internal rectus muscle of the eye is divided—and which, in many instances, render the operation only partially successful, or, by substituting a greater evil, wholly abortive—let me flatter myself that the facts on which those arguments are founded, from their importance, as well as from the unreserved and faithful manner in which they are detailed, may serve, in some degree, to compensate for any deficiency in my researches as a physiologist.

As it is probable that this volume, from the subject being one of general interest, will occasionally fall into non-professional hands, many may express surprise that I should have preferred illustrating my remarks by a series of cases so much at variance with those already published by others, and so little calculated to inspire confidence in an operation which, by almost universal testimony, is now considered to be one of the most invariably successful in surgery; especially when the necessary precautions are attended to in selecting proper cases for this mode of treatment. My apparent want of tact, indeed, in not imitating the example of my predecessors in this respect, and presenting my claims to the public in a more acceptable and attractive form, it has been already suggested, may cause the general results of my practice to be viewed by some in an unfavourable light, tending to my prejudice.

My readers, however, will recollect that he who is favoured with the largest share of experience, in any particular disease, is the person most likely to meet with the greatest number of irre-

gular cases. It is only fair, however, to observe that very few of the untoward events recorded in the following pages have occurred in my own practice, but in that of various professional friends, who have kindly permitted me to benefit by their experience.

Out of the several hundred examples of strabismus that have passed through my hands, either as subjects for opinion or for operation, nothing would have been more easy than to have selected a sufficient number of the most complete and undeniable cures for the purpose of swelling these pages to any extent that might have been thought desirable; nor would it have been less easy to have verified such a detail by parading in full, as others have done, the names and addresses of my patients for public reference, had I not considered such a mode of advertising myself unbecoming a regularly educated member of a liberal profession.

Every sensible and reflecting person must be aware that no operation in surgery can, by any possibility, be always equally fortunate in its results; and it appears to me that he who exposes the real value of any curative means, by honestly stating the true ratio and degree of success, or who points out the sources of failure—be it in only one untoward case — confers a greater benefit on the public, and contributes more to the legitimate advancement of the cause he espouses, than the man who unblushingly blazons forth a hundred examples of untarnished success, while

he conceals all the incidents of a contrary nature, which, if detailed with equal fairness, and the same circumstantiality, might serve as most invaluable beacons of safety to his professional brethren.

Such of the cases related in the following pages as appeared of sufficient interest to merit illustration by the pencil, have been delineated on stone, from nature, by Mr. W. Bagg, whose reputation for correctness as an artist is too well known to require any comment from my pen. On the contrary, his name being affixed to the drawings, spares me the necessity of insisting further on their accuracy.

In order to avoid unnecessarily complicating certain of the facts recorded, by tedious phy siological digressions, I have added an Appendix, in which is detailed a series of experiments on animals, instituted with a view of ascertaining, as far as was possible by such means, the probable effects of dividing the several orbital muscles in the healthy and unstrabismal eye. The results of this inquiry, though by no means so satisfactory or conclusive as could have been desired, are still of a highly useful and interesting nature; and if they do not absolutely solve the queries they were designed to answer, at all events convey certain hints of which we may advantageously avail ourselves when proposing to perform similar operations on the human eye.

14, Langham Place, Regent Street,
Nov. 21, 1840.

ERRATA.

Page 9, line 14, *for* "but" *read* "than."
" 11, " 25, and in several succeeding pages, *for* "centre of the orbit," *read* "axis," do. do.
" 46, " 25, *for* "exertion" *read* "extension."
" 70, " 10, omit the words "*by a partially paralytic state.*"
" 74, " 23, *for* "than" *read* "besides."
" 91, " 1, *for* "occurrences" *read* "occurrence."
" 95, " 7, *for* "point" *read* "hook."
" 198, 1st line of Note, *for* "intervenes" *read* "supervenes."
" 129, " 15, *for* "XI." *read* "IX."

INTRODUCTION.

THE division of the tendon of the adductor muscle of the eye, as a remedy for squinting, was originally proposed, I believe, by Dr. Stromeyer, of Hanover; but, to Professor Dieffenbach, of Berlin, is due the merit of first accomplishing this object. This he did about the beginning of the present year, and with such success that the fame of the operation soon travelled over Europe. In a late number of the Lancet (Sept. 5, 1840), it is affirmed that Mr. Anthony White, Surgeon to the Westminster Hospital, in the year 1837, surmised the advantage that might be conferred by the surgical means now in practice for the cure of strabismus; and that he even went so far as to experiment on animals, for the purpose of ascertaining the best and easiest mode of accomplishing the division of the tendon. It has also been stated that Sir Charles Bell proposed this operation many years ago. For the credit of English surgery I sincerely wish that either of these gentlemen had carried his inquiries a little further, and matured his ideas on the subject, that foreigners might not so frequently have the merit of anticipating us in scientific discovery.

Since its introduction into this country, Dieffenbach's operation has undergone several improvements, the most important of which is certainly that suggested by Mr. Bennet Lucas, who much facilitated its performance, by recommending the use of a blunt hook for the purpose of raising the tendon previous to cutting it across. He, at the same time, also rendered it much more safe, by abolishing the employment of the sharp hook as a means of fixing the eye-ball. Other modes of operating have been adopted by different surgeons, some of which, as will presently appear, deserve a preference under particular circumstances; though, as a general plan, I consider that which originated with Mr. Lucas to be infinitely the best in every respect.

The treatment of strabismus by surgical means being a novelty, we cannot expect every practitioner at once to sanction it; and even were all disposed to admit its claims to rank as an improvement in modern surgery, it would be injudicious to do so unhesitatingly, till a sufficient time shall have elapsed to establish its true merit to be considered as a permanent and harmless cure. A very important objection, however—one that has emanated from a high authority in ophthalmic surgery — has thus far proved to be chimerical; or, at all events, to have no foundation as a general rule.

On the supposition that an obliquity in the axes of the eyes may often be an expedient established by nature, in order to remedy a

defective state of vision in one or both organs, by allowing the image to be depicted on a more sentient part of the retina, it has been apprehended that, if this resource were cut off by dividing any of the muscles of the eye, the sight would become still more defective, in consequence of the object being then, perforce, figured on the faulty portion of this nervous expansion. Were this supposition correct, it is clear that the patient's condition would be rendered worse than before operation, because the agent by which the accommodation was brought about is thereby incapacitated. Doubtless, this theory is very specious, and may hold good when strabismus does proceed from the cause here alluded to; but practical experience proves to us that cases of this description are not only exceptions to the general rule, but extremely rare exceptions, and that the very converse of the proposition is the almost universal law. Besides, it is more than probable, even were we so unfortunate as to operate on an example of this description, that as soon as the muscle became re-attached to the sclerotica, and could resume its functions, nature would ere long have recourse to her old remedy, the strabismus would be re-induced, and sight restored to its former condition. Instead, however, of an imperfect state of vision being a cause of strabismus, ninety-nine times out of the hundred we find that impaired sight is a result of this affection, and that as soon as the deformity is removed the functions of the eye improve. The advantage, indeed, in

this respect, in many instances, is so considerable, that I regard it as of far more importance than the improvement effected in the personal appearance; although the latter object is that which usually induces patients to submit to the operation. The obliquity, it would seem, not only impedes the simultaneous use of both eyes, especially in persons who squint much, but by preventing the object from being depicted on that portion of the retina destined to receive visual impressions, confuses the sight. In many instances, moreover, when the eye is bound down by adventitious adhesions, or a thickened contracted state of the fascial, or submuscular cellular tissue, so as to materially limit its movements, there is reason to believe, as will hereafter appear, that the optic nerve is exposed to inconvenience sufficient to induce a really amaurotic condition of the retina; so imperfect do we occasionally find the sight to be in such examples. Under these circumstances, moreover, the patient is often near-sighted, not from the ordinary cause of myopia, but from being obliged to hold near his eyes whatsoever small object he looks at, in order to bring it in the direction of the axes of both eyes at once. Now, all these inconveniences generally cease as soon as the eye is set free, and vision is, for the most part, remarkably improved by the operation. Of this fact I could cite a multitude of examples; and thus far I have not heard any patient complain that the benefit so conferred is on the decline.

CASE I.—A woman on whom I operated some weeks ago, was so blind before operation, that she could not distinguish the features of the gentlemen who surrounded her; the eyes were both very much limited in their motions by fibro-cellular adhesions, and the pupils, especially that of the right eye, were so buried in the inner canthi, that she could only use one eye at a time. An hour after the eyes were liberated — for in this instance, contrary to my general practice, I operated on both at the same sitting — this patient was so far restored to sight that she could not only distinguish the features of every one present, but pick up a pin from the table; and her sight has steadily improved ever since.

CASE II.—A young lady, in whom I divided both of the adductor tendons under similar circumstances, informed me that, prior to the operation, she was not only obliged to hold objects very near her eyes in order to see them, but that, even when she did so, her vision was always obscure and misty; and that she was unable to use the organs for any length of time, from the uneasiness she experienced in retaining their axes so directed as to make them correspond. From the moment the eyes were set free she expressed her conviction that her sight was improved. It continued for some days to become clearer, and is now as good as need be in every respect; her eyes being extremely well placed, and the operation in every particular so perfect, that no blemish can be

detected in them without submitting the organs to a professional inspection; neither could it be surmised that she had ever suffered from any obliquity of vision whatsoever.

I could enumerate a multitude of examples, showing the fallacy of the doctrine, that, as a general rule, dividing the adductor muscle of the eye is calculated to injure the sight: but as the cases I shall have to relate, for the purpose of illustrating other principles, will most of them bear evidence of this fact also, I need not anticipate them at the present moment.

GENERAL OBSERVATIONS.

To divide the tendon of the adductor muscle really well, and to liberate the eye with *certainty* and in an *efficient manner*, so as to secure the utmost benefit capable of being conferred, at the smallest possible cost of suffering and inconvenience to the patient, requires much more dexterity, neatness, and address, than is commonly believed.

At first sight the simplicity of the operation is such, that almost every one is induced to attempt it, but comparatively few succeed to the full extent. To attain this delicacy and excellence, it is essential that the surgeon should perform the operation a vast number of times. That the first attempts, therefore, of the unpractised almost invariably prove only partially successful, cannot surprise us. I have myself operated on between two and three hundred individuals, as well as had opportunities of examining a great variety of cases operated upon by surgeons of every degree of skill, and I feel satisfied that the statements I make will be found correct by every impartial inquirer.

The original obliquity of vision, it is true, may be removed; but if, in its stead, there be substi-

tuted a staring, vacant, projecting eye, of apparently disproportionate size—and this is a very frequent result—or a disagreeable leer; or if a mere alteration only in the nature of the squint be effected, it is very questionable how far the expression of the eye is improved by the change.

The division of the tendon may have been perfectly performed, and still the operation be incomplete; for in many instances severing the muscle from its attachment is only a part of the means necessary for the cure of strabismus. The patient may lose the power of turning the eye *horizontally* inwards, so as to bury the pupil in the nasal canthus to the same extent that he could do previously; but if, in his effort to accomplish this movement, the pupil be directed obliquely either upwards or downwards, and only slightly inwards, we shall, in a number of instances, find that a portion of contracted fascia, condensed cellular tissue, or perhaps some apparently insignificant band of fibrous adhesion, still requires to be separated; and that if this further step in the operation be neglected, as it too often is, the modification of the original evil just alluded to will be found to persist. The operator, thoroughly satisfied in his own mind, from the extent to which he may have denuded the sclerotica, that he must have divided the whole of the tendon of the adductor, often erroneously concludes that this slight obliquity arises from sympathy, and that, in the course of time, it will entirely disappear. But unless we can imagine

that the unsevered parts will gradually relax, or become elongated, it is impossible that the eye-ball can ever emancipate itself thoroughly from its confined position. I have lately examined several cases of the above description, that were operated upon when this mode of relieving strabismus was first practised in this country, and do not find that time has thus far effected any amelioration in them, nor do I think it at all probable that further improvement will ever take place; but the contrary.

When the operation is complete in every respect, and only *one eye is affected,* no other muscle being implicated but the adductor, the patient is wholly incapable of directing the pupil inwards beyond the centre of the orbit, either in a horizontal or in an oblique line. When both eyes, however, are affected, especially if they have been so for any length of time, a slight cast towards the nasal canthus may still exist after the operation, when the eye is used in conjunction with its fellow, even although the tendon shall have been perfectly divided.

In the course of a fortnight or three weeks after the operation, if the tendon has been simply divided, and not disturbed or displaced by pushing the muscle back into the posterior and lateral part of the orbit with the handle of the scalpel, as has been recommended by some surgeons *, it appears, either that a new inser-

* Report by Mr. Charles Guthrie.

tion of the muscle takes place, so that the patient recovers, in a very considerable degree, the power of directing the pupil towards the nasal canthus; or that certain of the other muscles, by a concurrence of action subsequently acquired by the natural efforts to render vision single, enable the patient to perform this movement. If any reunion take place between the divided tendon and sclerotica—and experience proves that this does happen in every instance—the fact that it is almost always established without return of the original evil is very important, and militates against the practice of displacing the muscle, as above stated, after its attachments are separated. The examples of relapse that are alleged to have occurred, at least all that I have examined, are cases in which either the operation had been inefficiently performed at first, or in which, both eyes having been affected, the tendon has been divided in only one eye: some of the former I have cured completely by repeating the operation more perfectly, and many of the latter by operating on the other eye.

The direction of the pupil upwards and inwards, or downwards and inwards, after the division of the tendon, has been noticed by Mr. Liston, Dr. Franz, Mr. M'Murdo, and indeed by almost every operator, each of whom has explained it on a different principle. The theory which is most correct, therefore, remains to be proved by future inquiry.

In the report of Mr. Liston's cases, in the

number of the Lancet for July 18th, of the present year, Mr. Ancrum observes, "In some instances, after the internal rectus has been cut across, the patient possesses the power of turning the eye inwards and downwards; this *arises from contraction of the inner border of the inferior rectus.*" "Mr. Liston," he continues, "is in the habit of partially or completely dividing the muscle in all these cases." Now, I do not by any means call in question that, in some few instances, it may be necessary to divide the inferior rectus partially or completely, because I am satisfied that this muscle is very often involved in the production of the deformity, as well as the adductor. But when, after completely dividing the rectus muscle, the patient has still retained the power of directing the eye downwards, and *a little inwards*, I have almost always found, on instituting a very careful examination, that a few tendinous fibres, or a band of adventitious cellular attachment, generally situated above the tendon of the muscle, still remained unseparated. On dividing these the patient could no longer direct the pupil to the nasal canthus, nor carry it beyond the centre of the orbit. It is truly astonishing how very small a portion of this fibrous adhesion remaining unseparated is sufficient to mar the finish of the operation. These fibrous bands, or digitations, are sometimes seated very far back, even beyond the greatest diameter of the eyeball.

In the dead eye the cellular tissue is so delicate,

lax, and unresisting, as to be scarcely appreciable. Indeed, it is with difficulty we can imagine it capable in any way of contributing to the deformity. When endowed with life, however, and thickened, the bands formed by it are very powerful agents in retaining the eye in its unnatural position, and offer considerable resistance to the scissars on being cut. It would seem that these bands in many cases proceed from condensation of the cellular tissue connecting the muscle with the sclerotic coat, and are the result of that tissue having gradually adapted itself to the shortened state of the muscle. In some instances we find them strengthened by the effects of inflammation that has occurred during childhood; and in numerous examples there is reason to believe that it is the supervention of this apparently unnatural adhesion that renders the strabismus permanent; for at its commencement there can be little doubt that squinting depends on muscular spasm by no means necessarily persistent. I think, moreover, that I have observed this adherent fibrous character of the submuscular cellular membrane to be more extensive and marked in persons who squint most. The movement of the eye, then, *downwards* and *inwards*, or upwards and inwards, when the patient makes an effort to direct it to the inner canthus, after the complete division of the tendon of the adductor, arises, I apprehend, in numerous instances, from the natural action of the inferior or superior rectus muscle, whilst the eyeball is

still partially bound down by the tendinous bands of attachment adverted to; and all we have to do, in order to succeed in perfectly rectifying this diagonal and abnormal movement of the organ, is to continue the dissection sufficiently to separate completely these adherent fibres, however far back, high up, or low down on the sclerotica, they may be seated, provided this can be done with safety. I have met with this feature in the course of the operation very frequently, and have always overcome it by the means just stated. I am presuming only one eye to be affected, and the adductor alone to be concerned in the production of the deformity.

In no case have I ever cut the fibres of the inferior rectus, even when this muscle was evidently implicated, and in none have I ever dreamt of dividing the tendon of the superior oblique muscle, as Dr. Franz informs us he has done, in order to remedy a position of the eye upwards and inwards. Dr. Franz, however, it appears to me, has deceived himself in this respect. Indeed, I can scarcely believe that any one has yet divided either of the oblique muscles, or that such an extension of the operation will ever be necessary. If we consider the following statement of Dr. Franz attentively, I think we shall be disposed to doubt whether he divided the superior oblique muscle, or only some unusual tendinous expansion, or fibrous adhesion, such as above described, or perhaps the inner fibres of the superior rectus muscle. Indeed, the manner in

which he relates that he accomplished this part of his operation goes far to convince me that it could not have been the tendon of the oblique which he cut. "I proceeded," says he, "to the operation, and carefully and entirely divided the internal rectus muscle, as in all my former cases. I now removed the hook from the conjunctiva, and leaving the eye at rest, after the lapse of a few minutes I examined its state again, when I was not a little surprised to find that the division of the muscle had not proved efficient, for although the inversion was certainly modified, the eye was yet turned upwards and slightly inwards.

"From the direction in which the eye now stood, and its movements obliquely *upwards* towards the glabella, I was induced to think that the present state of this eye, the internal rectus having been entirely divided, would be well adapted for an experiment to investigate the true action of the oblique muscles; and as the patient bore the operation with very little inconvenience to herself, I determined at once to divide, first the superior oblique, in order to convince myself whether the present direction of the pupil depended actually on the action of the inferior oblique only, and then to divide the inferior oblique likewise, if the direction of the pupil should require it. I introduced the hook again through the conjunctiva, *and, without enlarging the wound,* passed the curved scissars under this membrane, cutting through the adipose and cellular tissues with their blades so directed as to meet the tendon of the superior oblique,

which I soon distinctly felt between the blades, and divided; as was proved by the resistance and the pecular sound with which the division of a tendon is always accompanied. On removing the hook again from the conjunctiva, and carefully examining the eye, I was not a little surprised to find that it was now perfectly straight, the pupil occupying its proper position. The division of the inferior oblique was, therefore, not requisite. The patient could not move the eye inwards, but in all other directions *the movements were free**." Now, it occurs to me that it would not have been so easy a matter to arrive at the tendon of the superior oblique through an opening made in the conjunctiva at so great a distance from it. And it appears equally strange that a muscle like the superior oblique should have been cut across, without the eyeball manifesting some more decided indication of such an event than the simple return of the pupil to its proper site. "The patient," Dr. F. informs us, "could not move the pupil inwards." This we might expect to result from the previous division of the internal rectus muscle, "but *in all other directions the movements were free.*" When the tendon in question is divided in animals, the violent action of the inferior oblique and other muscles indicates in a most unequivocal manner that such an operation has been accomplished, and the eye protrudes to an

* Medical Gazette, July 24, 1840.

alarming extent*. Having witnessed these results, I am disposed to suspect that those who state they have divided the tendon of the superior oblique, have misled themselves; and that, after detaching the principal band of fibres by which the adductor muscle is inserted, they have encountered some adventitious portion of fascial, or other fibrous attachment, such as already described, and which I have myself often found so situated as to easily mislead a person, desirous of achieving this feat, to believe that he had actually divided the tendon in question. Or, perhaps, in their search for the *insertion* of the superior oblique into the sclerotica, supposing them to have attempted its division near this point, it is quite possible that they may have divided some portion of the tendon of the superior rectus muscle; underneath which, in fact, lies concealed a considerable portion of that of the superior oblique.

From what I have myself experienced, I can very readily imagine any one falling into this error. Had Dr. Franz, indeed, divided the muscle he supposed he did, not only would the eye have protruded beyond the orbit to the extent of one-third its dimensions, but the patient in all probability would have been instantly blinded; as these were the effects which I found to result from performing the operation on a dog, in order to ascertain the facts.

* Vide Experiment, entitled "Division of the superior oblique muscle," in the Appendix to the present Observations.

Johnson's Case.

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Drawn on Stone by W B AGG

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Much diversity of opinion prevails in regard to the functions of the oblique muscles of the eye; any discussion, therefore, on this subject, would lead us into speculative controversy foreign to the main purpose of these observations. Hence, I shall reserve such remarks as I propose to offer on this question for the Appendix; more especially, as I am at present engaged in a series of experiments, calculated, I trust, in some degree, to elucidate this part of the inquiry, and which, it is hoped, will be completed before the latter portion of these remarks is sent to the press.

Before, however, dismissing the practical part of the inquiry connected with the foregoing question, it may be well to detail the following case — an exceedingly instructive one, as it affords strong evidence for believing that the only muscles requisite to enable the eyeball to move diagonally upwards and inwards, *i. e.* towards the nasal process of the frontal bone, are the superior rectus and the adductor.

CASE III.—A man—Johnson—presented himself for operation, who squinted in a most remarkable degree with the right eye, in the manner we have been considering, viz. *upwards* and *inwards*; so much so indeed, that, when the eye was at rest, nearly two-thirds of the cornea were concealed from view.—Vide plate II. AA. The gentlemen who examined this case previous to operation, viz. Dr. J. C. Williams, Mr. J. N. Thompson, of Nottingham, and Messrs. Smith and

Walker, surgeons in the immediate neighbourhood of that town, were all of opinion that either the superior or inferior oblique muscle was implicated in producing the deformity.

On dividing the tendon of the adductor, and completely liberating the eye from all confinement on its inner aspect, the pupil immediately darted directly upwards, so that more than one-half of the cornea was concealed under the superior palpebra (BB). In this position the eye remained fixed, unless the patient made a *great* effort to look downwards, which movement he could never so effectually accomplish as to enable the axes of the two eyes to correspond, and obviate double vision. On the third day after the first operation, I divided the tendon of the superior rectus, by cutting down upon it anterior to where that of the superior oblique passes under it. This I did in the same manner as I usually perform the operation on the adductor, by first dividing the conjunctiva and loose subjacent tissue, so as to lay bare the tendon, and then by inserting a flat blunt hook underneath the band of fibres, and snipping the latter across with a pair of scissars. The pupil, considerably dilated, immediately afterwards descended to very nearly its proper position in the centre of the orbit (CC), vision became single, and the case went on satisfactorily in every respect. The dilatation of the pupil afterwards gradually subsided. I have met with numerous instances of precisely the same description, as regards the direction of the pupil upwards and inwards, but never in any other

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Drawn from Nature on Stone by W. BAGG. *Printed by C. Hullmandel.*

case found it necessary to divide any tendon but that of the adductor, and to liberate the eye from such abnormal connections as I have described, that tended to confine its inner aspect. When in the course of an operation, after cutting across the band of tendinous fibres by which the adductor muscle is inserted, the eye has been turned upwards and inwards, or in the contrary direction downwards and towards the nasal canthus, I have always found some portion of fascial or adventitious adhesion to be the sole cause of the movement; the contraction of the superior or inferior rectus not exceeding that which was natural, but being productive of an irregular effect, because exerted on a tethered globe.

Subsequent reflection on Johnson's case, and the further experience of a similar example (that of Mr. C., Plate III.) in the practice of a professional friend, have induced me to believe that, in some few instances, when the pupil, *prior to operation*, occupies the position upwards and inwards adverted to, there may exist paralysis, either partial or complete, of the inferior rectus muscle; and which may, perhaps, not only have been coeval with the supervention of the strabismus, but be actually the source from whence the deformity emanated. As I was not consulted in Mr. C.'s case prior to the performance of the operation, and must rely upon his explanation of the position of the eye at that period, I have only given a representation of the appearances after the tendon was divided (DD), and the position of the pupils when

he attempted to direct both eyes downwards (EE). The gaping condition of the inner angle, and the general destruction of the natural contour of the right eye, are an evidence of the bad consequences that occasionally result from performing the operation in the manner to be presently denounced, by making a *clean dissection* of the inner surface of the sclerotica.

In Johnson's case, it will be observed that more than an usual effort was required to cause the pupil to descend; and that he could never, under any circumstance, lower it sufficiently to render the axes of the two eyes parallel. Now, in all other kinds of strabismus, the patient possesses the power of turning the pupil, without any great difficulty, in a direction contrary to that in which it is placed by the deformity when the eyes are in a state of repose. From what other cause, then, than a partial loss of power in the inferior rectus, was Johnson unable to look downwards, when he was desirous of moving the eye in that direction? And why, when the tendon of the superior rectus was cut across, did not the inferior rectus unduly depress the pupil, on the same principle that its antagonist muscle had elevated it when left at liberty to do so? I am further strengthened in the above opinion, because, in the second case alluded to, and which I have now repeatedly very carefully examined, the patient seems to have wholly lost the power of the inferior rectus muscle; it is completely paralysed; he cannot, by any effort, cause the pupil to

emerge from below the margin of the upper eyelid. It is much to be regretted that the movements of the eye, in this case, were not submitted to a careful examination before the division of the tendon was undertaken. An inability to direct the organ downwards would then, in all probability, have been detected, the present annoying consequences foreseen, and the operation have been abandoned. Unfortunately, few surgeons ever think of investigating the history of the deformity, or of subjecting the entire movements of the eyes to a rigorous examination. The absorbing question always is, which of the two organs is the one most affected? As soon as this is ascertained, by observing which pupil is most inverted when the patient directs each eye alternately to the nasal canthus, the operation is forthwith performed. Be it observed, the case is very different when the pupil, after the adductor is cut, assumes a position upwards and inwards, that it did not previously manifest. The cause of this it has already been attempted to explain; and even in cases in which this position of the pupil may exist prior to any steps being taken for the rectification of the strabismus, its connection with loss of power in the inferior rectus muscle is not to be considered as an usual, but as a possible, and occasional occurrence. If, however, in such case, we should find that the patient is incapable of freely using the inferior rectus, it might be well to pause before operating, lest we render the position

of the eye not only more unsightly, but less useful, by injudicious interference.

Whilst writing the above, a patient has just been brought to me by my friend Dr. Marshall Hall, in which the converse of the foregoing facts is illustrated. The person is affected with ptosis, paralysis of the levator palpebræ, and at the same time with a partial state of paralysis of the superior rectus of the right eye. Hence it would appear, that all the orbital muscles, either singly or in groups, may be thus affected—a position which will be further illustrated as we proceed in this inquiry.

It has been stated that one of the immediate occasional effects of the operation may be a trifling projection of the eyeball; the extent, however, to which this may occur is very variable, and depends, I conceive, much upon the manner in which the division of the tendon has been accomplished.

When the operation has been performed without injuring the conjunctival and other coverings more than is absolutely necessary, any increased prominence of the eye that may result is scarcely appreciable, and, in some instances, cannot be at all detected.

If, on the contrary, the eye has been liberated by submitting the sclerotic tunic to a *clean dissection*, and the investing membranes have been removed to an unnecessary extent, the eyeball is much more liable to start forward than when attention is paid to preserve the natural appendages and unimplicated textures entire.

If, as frequently happens, the faulty eye is of somewhat less dimensions than its fellow, this mode of performing the operation merits, perhaps, a preference. But if, on the other hand, the faulty eye be the larger of the two, a circumstance of equally frequent occurrence, then it is of the utmost importance to perform the operation in such a manner that all the natural attachments, not concerned in the production of the deformity, shall remain uninjured. The above mode of proceeding, moreover, is in general too severe; and, when no attention is paid to preserve the semilunar fold of the conjunctiva, it of course destroys the natural beauty and finish of the nasal canthus, often substituting in its stead a gaping cavity, and a widened state of the inner angle, so unsightly in appearance as to attract the notice of even a casual observer. (Vide D, right eye, Mr. C.'s case, Plate III.) When circumstances, then, lead us to select the operation by the forceps and scissars, to the exclusion of the blunt hook, care should be taken to preserve all those natural appendages and membranous folds of the eye on which the elegance and symmetry of the organ depend.

Another objection that I have found to proceed from removing more of the conjunctival covering than was absolutely essential to admit of a perfect division of the structures which hold the eye bound in its unnatural position, is the protracted manner in which the work of restoration is afterwards carried on, and the difficulty of repressing the exuberant growth of the reparative granulations.

Indeed, the difficulty is such that they occasionally withstand the application of escharotics, and require to be removed with the scissars; a measure which, though productive of only very trifling pain, always creates dissatisfaction. In a surgical point of view, perhaps, this may not be a matter of very great import; but children and nervous timid persons are with difficulty persuaded to submit again to what has to them the appearance of a second or third operation.

Another objection to this mode of operating is the necessity of fixing the eyeball by means of a sharp hook passed through the tunica albuginea, which not only gives considerable pain, but, in refractory patients, is liable to pierce and lacerate the sclerotica, or even to injure the retina.

But these are minor evils compared with sloughing of the eyeball and total loss of vision; an event which I know has happened when a clean dissection has been rather too extensively made of the sclerotica.

Under all these points of view, it appears to me a matter of great importance to separate or destroy the conjunctiva and other membranous attachments as little as possible, and to confine the operation, when practicable, to a simple free slit through the conjunctiva and subjacent coverings, down to the tendon, and to separate this latter by means of a blunt hook, in the manner first recommended by Mr. Bennett Lucas, previous to cutting it across with a pair of scissars inserted between the convexity of the hook and

Bentley's Case

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the sclerotic coat. I can produce abundant proof that the fullest benefit the operation can confer may be easily obtained by this mode of performing it, and that ten days or a fortnight are in general sufficient for recovery, without any subsequent application of scissars or escharotics; and, as before observed, when thus performed, unnatural prominence of the eye will be a very rare consequence of the operation.

Another unfortunate result, but by no means the fault of the surgeon, is the undue influence which the *external* rectus occasionally exerts after the eye has been liberated internally. For the most part this effect is not considerable, nor does it continue beyond a few days; indeed it very rarely occurs at all if the other eye be likewise affected, or other of the orbital muscles than the adductor be implicated in the production of the strabismus.

A very remarkable case of this description presented itself to my friend, Mr. J. N. Thompson, of Nottingham, which I had an opportunity of examining, when in that town.

CASE IV.—A girl (Bentley) of 13 years of age, of an irritable delicate habit, squinted inwards and downwards with the left eye. (Plate IV. AA.) On dividing the tendon of the internal rectus muscle, the pupil was instantly turned towards the external canthus in an unusual manner,—that of the right eye occupying its normal site,—and vision became double. It was now found that, on looking at any object placed immediately before her, she had the

power of directing the axes of both eyes correctly, so that no obliquity could be detected in either, and vision was single. If, however, without turning her head, she regarded any object placed a little at either side of her, the eye of that side was instantly turned outwards to a very considerable extent. When the object was placed on the left side, the eyeball turned so completely round, that a considerable portion, two-thirds, of the cornea, was concealed in the outer angle of the orbit, the opposite pupil occupying its proper position (BB). The most singular circumstance in this case is, that the external rectus of the sound eye, which it might be presumed would have been restrained by its antagonist adductor, should contract in the same inordinate manner, as exemplified (CC) same plate, though in a somewhat less degree, as that of the eye which had been subjected to operation, and in which the natural opposition of the internal rectus was of course destroyed.

CASE V.—A lady, Miss L., a patient of my own, had a slight cast in both eyes (Plate V. DD): the operation was performed on the left eye, that in which the obliquity was the worst, and the vision most imperfect; the result was in every respect satisfactory, as illustrated (EE), the left eye being straight, the right a little inverted as before operation. At the expiration of three weeks, as the defect in the right eye continued very marked, she was desirous of having the tendon divided in it likewise; having seen the

Miss Lee Case

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second operation highly successful a short time previously in a young person under my care who was similarly affected. The tendon of the right eye was therefore divided; immediately the external rectus of the left eye exerted an undue influence, and turned the pupil so much outwards, that vision became double, and a very unpleasant leer supplanted the original squint. It was afterwards found that she could direct both pupils with the utmost precision, when the object she looked at was placed immediately before her; but that if it were removed only a few inches to either side, and she continued to look at it without turning her head, the external rectus of the eye, on the side to which the object was moved, immediately exerted an undue ascendancy, and drew the pupil so much to the outer angle, that vision instantly became double, and a most ungainly cast to that side supplanted the original evil. (Vide FF, when she directed her eyes to an object placed at the left hand side of her; and GG, when she looked in the contrary direction.) This untoward symptom has continued for some length of time; but as it is now confined to the left eye, I am in hopes that it will ultimately be overcome, when a reparation of the nerves which preserve the consent between the movements of the eyes is sufficiently established; and I am the more sanguine in this expectation, as I have just received intelligence from Mr. Thompson that the evil no longer exists in Bentley's case. Still, it is possible that, in some instances, this over

action of the abductor may remain a permanent imperfection, and it may become requisite to divide the tendon of that muscle in order to remove it. The necessity for such an operation, indeed, has actually occurred in the practice of Mr. C. Guthrie.* Miss L.'s case not only shews the propriety of very maturely weighing the possible consequences of dividing the adductors in both eyes, but suggests some points deserving consideration in the mode of performing the second operation.

We cannot reflect on the phenomena which characterise these two cases, without attempting some solution of their peculiarities. In the first patient, it will be observed that, although only *one* eye, the left, was the subject of operation, *both* eyes respectively were brought under an undue influence of the external rectus, when this muscle was called into action by directing the axes of the eyes simultaneously to an object placed at either side of the individual, without turning the head. When the girl Bentley looked at any thing placed at the left-hand side of her, the cornea of the corresponding eye was partially buried in the external canthus, while the pupil of the right eye assumed its natural position near the inner canthus, and *vice versâ* when the object was placed to the right of her; though, certainly, not in so great a degree; the pupil of the left eye, moreover, not moving beyond the centre of

* Vide his Report.

the orbit. Her sight was under either circumstance double, and the position of the eyes that of a very unpleasant leer; but she could regard an object placed directly before her with the most perfect accuracy. In the second case, the young lady squinted with both eyes, though in no very remarkable degree. The first operation on the left eye was attended by every indication of the most complete success. At the expiration of three weeks the tendon of the adductor in the right eye was divided, and instantly the pupil of the left was turned outwards, and vision became double, at first, even when she looked at an object placed immediately before her. In the course of an hour or two after the operation, however, she acquired the power of directing the axes of the eyes with the utmost accuracy when the object was placed before her; but it was found, if she looked at any thing on either side of her, that then the external rectus of that side exerted so great an ascendancy as to completely turn the cornea to the external angle of the orbit, when she saw two objects instead of one. This undue action of the external rectus, however, was more marked in the left eye—that first operated upon—than in the right, in which, indeed, it now no longer exists.

These facts suggest several very important and interesting queries worthy the attentive consideration of the physiologist, the accurate solution of which would clear up much of the difficulty attending the theory of that singular sympathy which exists between the two eyes, in order that

when the eye is in a state of repose. It is also further reasonable to conjecture, that the natural sympathy which exists between the two eyes, and regulates the parallelism of their axes, will materially favour whatever tends to the accomplishment of this important object.

The abductor and adductor, it is true, are antagonist muscles, but their functions are performed quite independently of each other, and in connection with the corresponding muscles of the opposite eyes respectively; *i. e.* the abductor of the one eye and the adductor of the other act in concert, and modify or restrain the irregularities of each other in all the consentaneous lateral motions of the eye that demand an effort of the will. The external rectus, for example, of the right eye, is the antagonist of the corresponding internal muscle, but its controlling power, *i. e.* the power which regulates the extent to which it everts the pupil, is seated in the adductor of the opposite eye; and thus it is we are enabled to direct both organs laterally, so as to make their axes correspond.

If, then, the internal muscle of the left eye be cut across, its antagonist, as far as any consent which exists between the two eyes can produce an influence, has no disposition to contract unduly, unless from some of the causes to be immediately alluded to, because it is still in connection with its controlling power—the adductor of the right side, and the nerves which supply both with energy; and were it to turn the pupil of the eye, to which it is

attached, outwards, the adductor of the other eye, with which it operates simultaneously, must of necessity draw the pupil of the organ to which it belongs inwards; but this, if the eye be not affected with strabismus, it cannot accomplish in a *morbid* degree: consequently, the sound eye will exert a very powerful controlling influence over the movements of the one that has been the subject of operation, when the pupil is directed towards the temporal angle. Besides, it must be recollected, that the inferior and superior recti exert an influence by no means inconsiderable under such circumstances, although indirect, in maintaining the eyeball in a natural central position.

But still, in some cases, the eye does turn unduly outwards, after the adductor is incapacitated; and, such being the fact, the converse of the foregoing query next suggests itself, viz.:—Why, if there be so many restraining powers in operation, does the pupil ever turn towards the external canthus after the division of the adductor, all the other orbital muscles being healthy and entire?

This question may be solved in various ways.

1st. In certain individuals the balance of power, it would seem, in the orbital muscles, is so accurately adjusted, that an abductor which, it may be presumed, has acquired a little extra tone, by being for a time accustomed to oppose a morbidly contracted adductor and two obliques,* is

* From the experiments performed on the obliques, and related in the Appendix, it would appear that when either of these

too powerful when the allied antagonist force is weakened by the division of the most efficient part of its resisting power. Undue eversion of the pupil, we have seen, is not a common but only an occasional result of the operation; and when it arises from the simple cause just explained, the inclination towards the temporal angle generally ceases in the course of a short time—the morbid disposition to contraction being lost, either from want of the former resistance, or from being met by an equivalent degree of opposition as soon as a new union has taken place between the divided tendon and the eyeball.

2d. Supposing the obliques, or other of the orbital muscles, to have been previously implicated, then we may argue, with still greater reason, that, having been long accustomed to oppose so unnatural a degree of resistance, the external rectus has itself become hypertrophied, or acquired unusual powers of contraction; and that hence, on depriving one of its opponents of the power of action, those that are left are unequal to offer efficient resistance, and the pupil may be turned outwards. But this occurrence, as before stated, rarely ever

muscles is cut across, the adductor of the same eye also being divided, the ultimate action of the one which is left, after rotating the eyeball on its axis, is to direct the pupil outwards; but that when both oblique muscles are entire, and capable of counteracting each other in the first motion they impart to the eyeball, viz. that of rotation on its axis, there is reason to believe that they then aid the internal rectus, and are the principal agents in preventing the pupil being drawn beyond the axis of the orbit when the tendon of this muscle is divided.

happens, except in cases of squinting that are not of long standing, or so trifling in degree as to lead us to believe that no other muscle than the adductor is concerned in its production.

3d. If both eyes be affected with strabismus, we may naturally expect, when that which has been operated upon is directed outwards, that it will unduly approximate the external angle of the orbit; otherwise its axis would not correspond with that of its fellow, the pupil of which, at such a moment, is unnaturally buried in the inner canthus. The extreme turn outwards, therefore, is the position that the pupil necessarily ought to occupy, in obedience to that sympathy which regulates the simultaneous movements of the two eyes, and renders vision a single faculty. The remedy in this case consists in performing the operation on the other eye.

But we have seen, as exemplified in Bentley's case, that, in some instances, the eye *not* subjected to operation, and previously correct in all its movements, is liable to be unduly drawn to the external canthus when the abductor muscle is called into action, as well as that of which the adductor tendon has been divided. How, then, are we to explain this anomaly? We can only account for it on the principle that the operation has destroyed the mutually controlling power that existed between the co-operating muscles; but why it should do so in one individual, and not in another, I can offer no satisfactory reason. Neither can I well understand why, in Miss L.'s case, the

untoward circumstances that presented themselves should not have occurred till after the second eye was operated upon, and then in a short time have confined themselves to one eye—that in which the tendon was first cut. It appears to me that the abductor of the left side did not evince any disposition to inordinate action when its antagonising adductor muscle was divided, because it had not acquired any undue contractile power, and was still under the natural controlling influence of the internal rectus of the right eye, and the nerves by which that muscle is supplied. The obliquity of vision, moreover, was not great, and the motions of the eye by voluntary effort were very free: hence we may conclude, that the external rectus had not been habituated to contend against any unnatural resistance, which might strengthen its ordinary powers of contraction. But, for what reason, as soon as the second operation was performed, both abductors should evince a disposition, when called into action, to draw the pupil unduly outwards, is not very clear. It is true the muscles, with which they each previously acted in concord, were severed from their attachments, but the two obliques, as well as the superior and inferior recti, their remaining physical restraints, and which are usually sufficient to prevent the pupil being turned too much outwards, still continued entire. There evidently existed, therefore, some further sympathy between the two muscles respectively, dependent upon their integrity, and this ceased as soon as their attach-

ments were destroyed, and will, I have no doubt, be restored when they have formed new insertions into the sclerotic coat, and the nervous communication, by which their consentaneous movements were regulated, is renewed.

Mr. Guthrie, who seems to entertain the opinion that strabismus convergens may proceed from partial paralysis of the external muscle, explains this undue eversion of the eyeball, after the inner rectus has been divided, by supposing, in such case, the loss of power in the abductor to be only trifling in degree; so that, when the muscle is left free to act, its contraction is too powerful for the diminished resistance it has to contend with. "This deficiency of power," he argues, "may be in various degrees, and when the effective and healthy muscle is divided, it does not follow that its opponent should be able to act, so as to cause a squint in the opposite direction. If, in paralysis of the face of one side, the portia dura of the seventh pair of nerves were divided on the other side, the mouth, on an attempt to laugh, would remain stationary: it would move neither way, or in a very slight degree. It is on a similar principle that, on the division of the internal straight muscle of the eye, it does not roll permanently outwards, but generally attains, after the first effects have subsided, a central position only. It must, however, be admitted, that if the influence of the external rectus is only partially weakened, the eye may be turned outwards, as I have shown did permanently occur in two instances, and may

occur in others. It is but rarely entirely destroyed, for the eye can almost always be moved outwards, and sometimes has a tendency in that direction for several days; but it must be borne in mind that it is only a muscle, and not the trunk of a nerve which has been divided, and that the inner fibres of the superior and inferior recti muscles may be in some degree antagonizing forces, calculating but little on the oblique muscles which may exert an influence we cannot fairly estimate." Although there can be no question that convergent strabismus very often does arise from the cause presumed by Mr. Guthrie, and that the above theory is supported by the fact that all of the orbital muscles may be singly or conjointly affected with paralysis, yet we must seek some other *rationale* of the circumstances attending Bentley's and Miss L.'s cases.* This theory does not explain why, in the former instance, the sound and intact eye should have been everted, when the external muscle was called into action, equally as well as that which had been the subject of operation; and it leaves us equally at a loss to understand, why, in Miss L.'s case, neither eye should turn outwards until after the division of the adductor tendons in both.

If apparent identity of origin, and intercommunication of nerves in their course, were calculated to produce similarity of function, or mutual co-operation in the action of the muscles to which

* Since writing the above I have seen two more cases similar, in every respect, to Miss L.'s, and one resembling Bentley's.

they are distributed, we should experience much less difficulty in satisfactorily explaining many of the phenomena, at present apparently anomalous, that attend the division of the internal and external orbital muscles in some cases, because the adductor and abductor moving powers are supplied by nerves, the third and sixth, that may be almost said to have a common origin, and are associated at numerous points with each other in the formation of particular ganglia and plexuses; thus,

The third nerve, motor oculi—and sixth nerve, abducens oculi—both arise from the tract of the fibres of the corpus pyramidale (tractus motorius). These fibres are continued through the pons varolii into the crus cerebri; so that, although the sixth nerve issues from the brain at the upper part of the corpus pyramidale, and the third from the crus cerebri, they may be considered, in point of origin and function, as a single nerve, merely separated by the breadth of the pons varolii.

In addition to this apparent identity of origin, the third and sixth nerves communicate very freely in the cavernous sinus, by means of the carotid plexus; and indirectly through the medium of the ciliary ganglion, carotid plexus, and superior cervical ganglion of the sympathetic nerve. The first of these communications is established between the inferior division of the third nerve, which supplies the internal rectus muscle, and the ciliary ganglion; the last between the sixth and the superior cervical ganglion; while the carotid

plexus is the bond of communication between both.

Unfortunately for the satisfactory theory that might be founded on these facts, to account for the consent that exists between the motions of the two eyes, the researches of Drs. Monro, Whytt, Müller, Alison, and others, have, I believe, been quite successful in establishing—

1st. That although nerves may lie in juxtaposition in the same sheath, they never absolutely anastomose.

2d. That *apparent* identity of origin does not, by any means, imply identity, or even similarity, of function. And,

3d. That all nerves perform their functions independently of each other.*

For want, then, of a more precise and satisfactory *rationale* of the circumstances attending the girl Bentley's case, although liable to innumerable objections, it appears to me that we must be content for the present to adopt the theory of Professor Alison, "that the sympathetic movements of the eyes, like sympathies in general, proceed from *mental sensations*, and that these organs sympathise with each other only so far as the sensation, which is the natural and appropriate stimulus of the one, is excitable by irritation of the other.

The opinion of Mr. Walker, of Manchester, that

* Vide an article, by Professor Alison, 2d vol. of the Edin. Med.-Chir. Transactions.

the lateral parallelism of the eyes is preserved by the action of the superior oblique muscle,* although very ingenious, is of course completely negatived by the results that have uniformly followed the division of the adductor. Were Mr. Walker's views correct, we should expect that the eyes would preserve their consentaneous movements inwards after division of the internal rectus, because the superior oblique still remains uninjured for that purpose; but we find the reverse. The eye in the majority of cases, *i. e.* if the adductor alone be in fault, cannot be turned inwards either in conjunction with its fellow, or consentaneously in this direction, when its fellow is turned outwards. And when, under certain circumstances — already noticed, and to be presently still further insisted on — the pupil does turn a little inwards after the operation, we now know that this movement is more frequently the result of the conjoined action of the inner fibres of the superior and inferior recti muscles, than dependent on the contractions of the superior oblique; and that cutting these inner fibres, though not the most judicious mode of proceeding, would, in the greater number of cases, rectify the position.

To return, however, from this digression, and resume the main object of the present portion of our inquiry:—there are other sources of failure

* Vide Philosophy of the Eye, by John Walker.

of which it is of the utmost importance the surgeon should be fully apprised, previous to subjecting his patient to operation—that his sanguine expectations of success may not be disappointed, and his prognosis belie his practice. When, during childhood, the eye has been repeatedly affected with strumous, or other inflammation, of which, in the absence of more positive information, we often perceive evidence in the existence of nebulæ and specks on the cornea, we may find the whole of the muscles, and investing cellular tissue of the eye, so extremely adherent to the sclerotica, that it would be imprudent to detach them to the extent necessary to liberate the globe in a sufficient degree to admit of its assuming the proper position, even were the rectus muscle and membranous attachments on the exterior of the organ to have escaped the ravages of the disease; which, under such circumstances, seldom happens.

When, then, we find the motions of the eye very limited, and that the patient is incapable of bringing the pupil, by an effort of his will, to the axis of the orbit,—having previously suffered inflammation, either during childhood, from accident, or other cause,—we should consider well the probable degree of success before we operate.

I have met with a few examples of this description in my own practice, and have witnessed several in that of other surgeons.

Case VI.—In one instance, a man was ope-

rated upon in Nottingham, on one eye, by my friend Mr. J. N. Thompson, and on the other by myself. All the investing structures of the inner periphery of the eye were found to be thickened, contracted, and infiltrated to such a degree, that they cut like cartilage, and required both extensive and careful dissection to separate them from the sclerotica. Fortunately, the mischief was confined to the inner portion of the sclerotic surface, so that, when the eye was liberated at this part, the external muscle had power to draw the pupil into its proper situation, and the case did well. This man had two small specks on the one eye, and a nebulous opacity on the other. Notwithstanding this disadvantage, his vision was much improved by the operation, as his eyes were previously buried in an unusual manner in the nasal canthus, from which position he could move them but in a very slight degree, being only able to bring the pupils alternately, by the greatest effort of the will, to a point scarcely midway between the inner canthus and the centre of the orbit. His sight was defective, I imagine, not only because he could not see any object he looked at with both eyes at the same time, but because it was difficult for him to turn his eyes sufficiently outwards to admit of the object being depicted on the sentient part of the retina, destined to transmit visual impressions to the sensorium.

May it not happen, when strabismus is very marked, and the eye confined, as in this example,

that the optic nerve suffers inconvenience from being slightly bent on itself; partial amaurosis being a frequent attendant on squinting?

CASE VII.—I afterwards operated upon a lady —Miss T. (Plate VI.)—whose right eye (A) was turned so much inwards that it was with difficulty she could draw the pupil from the nasal canthus: this patient had been twice couched for opacity of the lens of this eye, and had, on each occasion, suffered from severe inflammation afterwards. She informed me that the obliquity of the eye had been considerably increased, and its freedom of motion much diminished, by the inflammatory attacks she had experienced.

I found the same adhesion of muscular, tendinous, and cellular tissue in this case that I have already described. After the operation the abductor did not turn the pupil sufficiently outwards, though it was able to draw it, by an effort of the will, to the axis of the orbit; and gradually, in the course of a few days, it acquired considerably more power; from which it would appear that the external muscle, as well as the internal one, was not only bound down by morbid adhesion, but had also been kept on the stretch for so long a time that it had lost its contractility; and that it was from this state of preternatural tension, in all probability, that it at first recovered: in the same manner as the muscular fibres of the bladder lose, *pro tempore*, their

Miss T's Case. *Pl. 6.*

A

C

B

D

Drawn from Nature on Stone by W BAGG *Printed by C. Hullmandel.*

contractile power, when this viscus has been over distended by retention of urine.

A few days ago I received a letter from this lady, enclosing a sketch of the present average position of the pupil, drawn by her medical attendant, Mr. H. Gisborne, of Derby. This, it will be seen, by reference to the engraving (B), is now very nearly natural; although she informs me that it occasionally inclines a little more to the nasal canthus than here represented, but is capable, on the other hand, of being drawn proportionally outwards when she makes an effort to turn it in that direction.*

The fact of the external muscle requiring time to recover the contractile power, of which it would seem that it is deprived by long-continued extension, I have frequently witnessed, and always found, in such case, that the patient was unable to bring the pupil to the axis of the orbit previous to operation.

CASE VIII.—An example of this kind occurred to me at Derby, when I was assisted by Mr. Douglas Fox, Mr. Wright, Mr. Godwin, and other surgeons of that town, who very kindly procured a large number of patients, for the purpose of aiding in making the present observations. In the case alluded to the woman was unable to turn the pupils sufficiently towards the centre of

* For further remarks on this case, vide letter of Mr. Gisborne, in the Appendix.

E

A

G

L

H

K

Drawn from Nature by W. BAGG. *Printed by C. Hullmandel.*

had squinted from the time she was three months old, and the deformity was not only marked in a most extraordinary manner, but the right eye (R) was so fixed, from repeated attacks of inflammation in childhood, that she could not cause the pupil to emerge from the nasal canthus of the orbit. Her wish that the operation should be performed arose more from the desire to have her sight amended than from any anxiety that her personal appearance should be improved; as she found she could never see any object with both eyes at the same time, unless it was held close to her face and in a particular position. Even when thus accommodated, her sight was very obscure, and the effort to obtain this conjoint use of the eyes became distressing if long continued.

I operated, in this case, first upon the right eye, but found that the pupil did not turn outwards in a manner by any means satisfactory (vide G). Being convinced that both eyes were permanently affected, and that other muscles than the adductors were involved in the production of the deformity, I waited a short time (about half an hour), and then performed the operation on the other eye also. In both I met with thickening of the submuscular tissue, and adherence between it and the under surface of the muscle and its sheath, similar to that I have already described. Even after the liberation of the second eye, the pupils only emerged in a trifling degree from their unnatural position; but in the course of the evening I found that they had made considerable advance,

and that she had acquired the power, when she made the effort, of turning them to the axis of the orbit alternately. From this time her case progressed satisfactorily, and, at the expiration of fourteen days, the pupils had attained the respective positions delineated in the annexed engraving (H K). Her vision is materially improved, and she now sees objects with both eyes at once.

That the foregoing, and similar cases, have not occurred in my practice alone, but have presented themselves equally to other surgeons, may be inferred from the following extracts from Mr. Guthrie's Report, and from Mr. Lucas's Observations:—

"In some rare and obstinate cases," the former writer observes, "the eye, almost immediately after the division of the muscle, returns to nearly its pristine state of obliquity; and these are, I presume, the kind of cases in which it has been thought necessary to divide, or to attempt to divide, other muscles than the one originally intended to be operated upon; and although the division and separation of the muscle and its attachments, in the manner I have especially indicated, in every direction until the outer or sclerotic coat is fully exposed to a considerable extent, enables us to succeed in most instances in effecting the object in view, it does not always do so; and in a few cases I have been obliged to desist without bringing the eye to an exact central position." And in Mr. Lucas's treatise we find the following passage:—

"Notwithstanding that the muscle be divided in the most satisfactory manner, and even a portion of it cut away, the eye in many cases will be found still inverted. I have ascertained beyond all doubt that this inversion is owing to the condition of the sub-muscular and sub-conjunctival fasciæ. When the inner rectus muscle is fairly divided, the mark of its semicircular insertion, with minute fuzzy tendinous fibres adhering to it, are as plainly discernible to the naked eye as the scissars with which the operation is performed; the inversion of the eye, therefore, cannot in such cases be owing to the inner rectus muscle. But if the sub-muscular and sub-conjunctival fasciæ be examined, they will be found strong and dense, and upon freely dividing them, both upwards and downwards, with a forceps and a pair of scissars, the eye in most cases will become perfectly straight. I say, *in most cases*, because it sometimes happens that these fasciæ are intimately adherent to the sclerotic coat for its inner extent, and the operator will be obliged to dissect them from it, leaving the sclerotic coat completely bare. I have had to do this in ten or a dozen cases, and the eye afterwards took the desired position, without the slightest bad consequence following the operations. When this unnatural adhesion of the fasciæ was present, I have invariably remarked that the conjunctiva, upon making its section, was not connected to the parts beneath it in the same loose and delicate manner as in the perfect condition of the eye, but that it was thicker than

natural, and could not be raised freely with the sharp hook. At first, I thought that, in inserting the sharp hook, I might have gone too deep, and I withdrew it; but, upon again inserting it into the conjunctiva, I found this membrane in the state I have described, and had afterwards to separate it freely before the other steps of the operation could be proceeded with. When this condition of the conjunctiva exists, the operator may be prepared for a similar condition of the cellular tissue and fasciæ beneath it, and for a tedious operation, in comparison with that where the conjunctiva is loose and moveable, and the other parts in a similar state."

When the eye does not completely emancipate itself after the tendon is divided, we should, in the course of a few hours, close up the sound organ with a compress and bandage, and desire the patient to use the eye that has been the subject of operation. This precaution should be continued until it may be presumed that the tendon is re-united. In the meantime the pupil will be much more everted than if the eye had not been thus freed from the sympathetic control of its fellow, which would have retained it constantly more or less morbidly inverted towards the inner angle of the orbit.

Another cause of failure is want of judgment in selecting the cases of strabismus that are proper for division of the tendon.

Such, unfortunately, is the mania for this operation, that all who squint are deemed proper

subjects for the test of surgical skill. But there are numerous examples, in addition to those already indicated, that ought not to be treated by this means.

CASE X.—A girl was shewn to me who had been operated upon, and whose eyes afterwards turned spasmodically in every possible direction. On inquiry, it appeared that she had twice suffered from chorea, and that the squint was a sequela of that disorder. At times, for weeks together, no obliquity of vision was perceptible; the affection would then recur, and continue for an indefinite period. Her eyes were very unsteady, and it was quite evident that these relapses were local returns of her former ailment, dependent, in all probability, on disordered bowels, or on temporary mental, or other, irritation. The treatment in this instance should have been medical; and so it ought to be in all cases which we are informed are intermittent in their nature, and seem to depend on gastric disorder, or on acute disease, and are evidently only the temporary indications of a disturbance of that intimate connection which subsists between the motor nerves of the eyes and the sympathetic nervous system.

The permanency of the affection should be well established before any operation is had recourse to. And when so established, there are many examples of strabismus that ought not to be interfered with. It would be improper to operate on cases that proceed from a disparity in the focus of the two eyes,

or on such as are connected with an imperfect state of the vision, arising from other causes. "When one organ is perfect in this respect, and the other imperfect, the latter, in its retinal functions, interferes with the accurate use of its fellow, and induces nature to set about a process in order to rid herself of this annoyance: the imperfect eye is then turned out of the axis of vision by an increase of action in one of the recti muscles, at first temporary, but in time, becoming habitual; the one muscle being possibly increased, the other diminished in bulk. But even here the normal direction may, in most cases, be temporarily restored by the patient's efforts whilst the sound eye is closed.

"In those forms of squint depending on corneal and other opacities, and on malposition of the pupil, there is modified muscular action to adapt the eye to receive the due impression of light which the situation of the opacity or the pupil would otherwise have prevented*."

CASE XI.—A young man (R. H——, æt. 20) presented himself for operation. He squinted very much with both eyes (vide Pl. I, Frontispiece, figs. 3 and 4). During childhood he had been, on several occasions, afflicted with membranous inflammation, which had produced a considerable opacity on the cornea of both eyes. The inner

* Hocken on the Pathology of Strabismus, Medical Gazette, Sept. 11, 1840.

portion of each pupil was partially obscured by these opacities; so that he was obliged, in looking at an object, to cause the pupils to converge, in order to admit of the rays of light passing through their unobstructed portion. The strabismus, then, in this patient's case, was evidently a resource of nature to enable him to use his eyes when looking at any object near him; and at the same time it was a means of enabling him to avail himself of the advantage of both eyes on such occasions. It was further found, if one eye was closed, so as to allow the pupil of the other to assume its natural position, that he could not, at such time, see any thing placed immediately before him, and that, if the object were held to the side most favourable for allowing the rays to fall upon the retina, still the vision was undefined and obscure; but on opening the closed eye, and allowing the two pupils to converge, then the object could be brought immediately within the sphere of the vision of both eyes, and he saw very well, though by no means perfectly. It need scarcely be added, that this case was not considered a favourable one for operation, and the patient was advised to rest content with his deformity, unless the opacity could be removed; which, from its density, is very doubtful.

An ulcer of the cornea may be the first originating cause of strabismus, since here the pain attending its progress is relieved by turning the eye completely away from the influence of light, and also, as Dr. Mackenzie has explained, by

easing the friction of the ulcer in the natural movements of the organ. The increased and irregular muscular action thus produced is attended with a squint, which, by constant repetition, at length becomes habitual, as in the former case.

Still there are instances in which, after the sight is destroyed by the causes that produced strabismus, such as opacity of the cornea, amaurosis, and similar diseases of the eye, the operation may be undertaken with the view of improving the personal appearance alone of the individual.

Case XII.—A young lady, Miss F. (Pl. VIII), applied to me under the following circumstances. She squinted very much with the left eye (B), and at times with the right; but in so trifling a degree that there was reason to believe the latter organ to be only sympathetically affected. This patient suffered in infancy from purulent ophthalmia, which had not only rendered the cornea nebulous, but also produced capsular cataract of that peculiar circumscribed kind which indicates itself by an opaque spot on the centre of the capsule (vide same eye). She had also frequently, during early life, suffered much from ophthalmic inflammation, particularly of the left eye; which, from the altered colour of the iris, the somewhat sunken state of the eyeball, and the dirty unhealthy hue of the sclerotica, there was reason to believe had on some occasions affected the deeper-seated structures of the globe. Her sight was almost destroyed in this eye;

Pl. 8.

Fellmandel

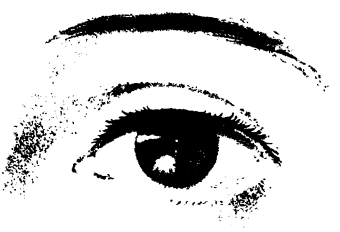
Miss Fs Case. *Pl. 8.*

A

B

C

D



Drawn from Nature on Stone by W. BAGG. *Printed by C. Hullmandel*

she could not do more than distinguish light from darkness. Her object in requesting to have the operation performed, as she was a good-looking girl in other respects, was simply to have the unpleasant expression imparted by the squint remedied. She did not expect that vision would be in any way improved, neither did I anticipate any such result. The operation was performed—the eye protruded a little, so as to be a match in prominence for its fellow, and the pupil also resumed its natural position (D). In this case the tendon was unusually strong, and the muscle and fascial coverings adherent in a remarkable manner, and over an extraordinary extent of surface.

When not congenital—which I believe it very rarely is—the disorder, no doubt, in numerous instances, especially in such as proceed from disorder of the primæ viæ, dentition, and similar causes, is for an indefinite period a sympathetic spasmodic affection, more or less evanescent or intermittent in its nature, and should for a length of time be regarded as such.

The period at which it may be viewed in any other light will, of course, vary in different individuals, and must be dependent on a multitude of circumstances, of which every practitioner is capable of judging, when once his attention is directed to the subject, and which, therefore, need not be insisted on in the present remarks.

OF DOUBLE STRABISMUS, AND THE POWER THAT PERSONS WHO SQUINT POSSESS OVER THEIR EYES.

At first sight it may appear unnecessary to warn those who have not directed their attention to the subject of strabismus, that they are very liable to select the wrong eye for operation; but I can assure them that it is often no easy matter to determine which side is most affected, or whether the individual squints with only one or both eyes. Even when both eyes are affected, they are not inverted simultaneously; although, when the one pupil is very much concealed in the nasal canthus, the other may also incline somewhat inwards at the same time; or one eye may remain in the centre of the orbit, while the other is turned upwards and inwards. Some patients will for a length of time use the same eye; but if the apparently correct organ be covered over for a moment, it will in turn become the displaced eye, the other occupying its natural position in the orbit.

Mr. Crommclinck informs us, that having had an opportunity of examining a great number of persons affected with squinting, he is disposed to confirm the statement of Buffon, "that strabismus never affects both eyes simultaneously." "Where one eye," says he, "is much affected, the other, at first sight, no doubt seems equally so; but when operation restores the distorted eye to its natural position, the opposite one loses its apparent

deviation either immediately, or after the lapse of a short time."*

In the majority of instances this opinion is correct; but I cannot assent to the statement, that strabismus "never affects both eyes simultaneously," because I have seen very numerous examples to the contrary, and have been obliged to operate on the second eye also; and this I have done not only with the effect of totally removing every vestige of strabismus, but with the still further advantage of leaving both eyes so precisely similar in general contour, size, and appearance, that even the most critical observer could detect no trace of former distortion, nor perceive any evidence that an operation had been performed, beyond the slight remains of cicatrix resulting from the wound made in the conjunctival covering.

Unless a case will stand this test, I do not consider it entitled to the epithet *perfect*, since I can produce, for the satisfaction of the curious or incredulous, numerous examples of this degree of perfection. Every thing short of this, although the original obliquity may have been removed, I consider an evidence of only *partial* success. I by no means, however, wish it to be implied that the surgeon is to be considered worthy of censure, if this degree of accuracy be not attained in every case, because I am well aware a multitude of circumstances may occur, over which the operator has no control, to defeat his best efforts. All I

* Dublin Medical Press, No. 88.

would be understood to argue is, that success, such as I have described, may in a multitude of instances be attained, and that numerous cases, which might be successful, fail for want of more skill and judgment on the part of the surgeon.

But to return to the question, whether squinting ever occurs in both eyes simultaneously. I believe the more general rule to be, that the distortion very rarely *assails* both eyes at the same precise period, but that in the course of time both may become *affected;* the second being gradually implicated by sympathy, or by the unconscious efforts which the patient makes to render the axes the same in both organs, in order to obviate double vision. And although for a length of time the distortion may continue to be of such a nature that removing it from the eye which was first attacked will remedy the defect in that subsequently involved, yet, in a great many cases, it becomes a permanent disorder in both; especially if, during its continuance, the eyes have been the subject of strumous, or other inflammation, calculated to produce any thickening, contraction, or other morbid change, in the sub-muscular cellular tissue. I have always found, when the operation consisted of more than dividing the tendon, and the strabismus was at the same time of long duration, that ultimately the second eye required operation also, before the position of these organs was rendered perfect in every respect. It is always proper, however, to operate on only one eye at a time, and, of course, we ought to select that

which is the most faulty, namely, the one primarily affected, and afford the other a chance for a week or two of rectifying itself without an operation.

"The degree of power," says Mr. Guthrie, "that a person possesses over his eyes, is occasionally very doubtful on the first inspection of them, both eyes squinting in turn or together, and it is only after a little delay that the really defective eye can be clearly ascertained; whilst in others the motions of the eye are altogether so irregular, and so little under control, that it becomes doubtful which muscle should be divided, or whether it would be proper to attempt any operation at all." When, then, we cannot determine this question by inspecting the eyes, and desiring the patient to look at an object placed alternately on each side of his nose, so as enable us to estimate which pupil is capable of being turned most inwards, we shall generally be assisted by the knowledge which the individual possesses of his own case; except in children, when we must either rely on our own judgment, or on such information as we can obtain from the parents or friends of the party. The sight of the eye most affected is very often somewhat impaired, and in many cases, as has been already stated, it is partially amaurotic. Indeed, I hold one of the most important results of the operation, in numerous instances, to be the subsequent gradual improvement of vision. A person who squints considerably cannot see an object placed at a little distance from him with

both eyes at once: hence, many persons affected with strabismus imagine themselves to be near-sighted, because, in order to see an object distinctly, *i. e.* to obtain the advantage of seeing it with both eyes at the same time, they are obliged to hold it near the face, that they may bring it within the axis of each simultaneously. But as soon as the distortion is removed by operation, not only is this near-sightedness cured, but the imperfection of vision proceeding from the image not being depicted on the most sensitive part of the retina, that destined to receive visual impressions and transmit them to the sensorium, very soon ceases.

Although, as just remarked, the degree of power possessed over his eyes, by a person who squints, is occasionally doubtful, in the majority of cases it is by no means limited; on the contrary, by an act of volition, we shall find that the eye is in general capable of the same movements, and to an *almost* similar extent, as if it were in every respect free. If the palpebræ of the best or sound eye be closed, and gentle pressure be made on it, so as to steady the globe, the faulty eye, provided it be not prevented by any unnatural adhesion, or other morbid change of structure, generally starts immediately from its abnormal situation into the proper position that it ought to occupy, nearly midway between the extreme boundaries of the inner and outer angle, and is capable of being turned outwards to almost any natural degree. But as soon as the sound eye is uncovered, and the voluntary

effort is discontinued, the distorted one returns again to the inner canthus. It can also be directed outwards, in unison with its fellow, when the individual looks at an object placed at the corresponding side of him. In short, the patient can move his eyes in any direction, and almost to any natural extent he chooses; but as soon as the voluntary effort ceases, they yield to the morbid power by which, when quiescent, they are controlled, and the obliquity returns.

"It is of importance," observes Mr. Lucas, "in all cases of convergent strabismus, to examine carefully the condition of both eyes before operating, lest, when one eye is restored to a natural position, the other becomes inverted; and, although this is actually what occurs in such cases when the inner rectus muscle of one eye in double convergent strabismus is divided, yet, if the surgeon be not aware of the fact, and do not prepare both the patients and their friends for the consequence on the eye opposite to that operated upon, he will get the credit of substituting one squint for another.

"To ascertain the state of both eyes, and the actual amount of deformity which exists, I have found the following method most satisfactory:— If it be the right eye which is inverted, and the patient is employing the left for vision, I place my hand obliquely over the left eye, in such a manner as to hide all objects in front of it, but keep the hand sufficiently raised at the temporal margin of the orbit to enable me to watch its

movements. I then desire the patient to exercise the eye which is uncovered; and if at the time that he brings it to the centre of the orbit, the covered one retreats into the inner canthus, the case is one of double convergent strabismus, and both eyes will require to be operated upon; but if the contrary occurs, if both eyes are at this period straight, or even if the covered eye has but a slight inclination inwards, the case is one of single convergent strabismus, and the inner rectus muscle of one eye only will require to be divided. I have in several instances seen the eye which was not operated upon have a slight inclination inwards for many days after the operation; but, when the healing process was completed, and both eyes were freely exercised by the patient, this inclination inwards gradually became less and less."—*Op. cit.* p. 48.

A very satisfactory method of detecting which eye is the one most affected is to desire the patient to gently close the eyelids of both; and then, in the course of a few seconds, when the muscles may be presumed to have been allowed sufficient time to place the pupils in the position they usually occupy when the patient is asleep, to suddenly separate the palpebræ for him with the finger and thumb of each hand respectively, so as to take the eyes, as it were, by surprise. On thus unexpectedly opening the eyelids, we shall always find the pupil of the organ principally affected to be that most concealed in the nasal canthus of the orbit. When both eyes are implicated in

pretty nearly an equal degree, we shall find, if the experiment be repeated a few times, that sometimes the pupil of one eye, and sometimes that of the other indifferently, and without any consciousness or control in this respect on the part of the individual, will most approximate the nose; generally, however, the pupil of the more faulty eye will be that most frequently out of place, and always in the greater degree.

CASE XIII.—As a practical example of the extent, as well as of the uncertainty, of the motion that may be often observed in the eyes of persons who squint, when the movements of the organ are not restrained by an unyielding or shortened condition of the inner muscle, by thickening or contraction of the submuscular or cellular tissue, adventitious adhesions, or the like, I shall relate the particulars of a well-marked case.

G. T., a young lad of 13 years of age, squinted very much with both eyes, but more especially with the left. When the eyes were quiescent, the pupils were both directed inwards, and somewhat upwards. If the eyelids were closed, and suddenly opened, sometimes the one pupil was found to be in the inner canthus, while the other occupied nearly the centre of the orbit; but it was involuntary on his part which pupil emerged from its concealed situation; generally, however, it was that of the right eye.

On looking towards an object placed at the left-hand side of him, the pupil of the right eye was

almost entirely concealed in the nasal canthus of that side, while the cornea of the other eye was half hid under the outer angle of the left orbit. The reverse of these positions was observed by the organs respectively when the lad looked at an object placed at the opposite side of him; but certainly not in so marked a degree.

By an effort of the will, if he looked at any thing placed immediately before him, he could direct the axes of the eyes, so as to see the object with both organs at the same time; but the left eye always converged most towards the nasal angle of its orbit, and the exertion could not be continued long without creating uneasiness. His sight was not much affected.

The obliquity of vision was reported by his mother to have supervened within a few days after birth, and was in all probability occasioned by the nervous irritation produced by retained meconium, as he was attacked with convulsions; and these seldom occur at this early period from any other cause. Had they depended on cerebral disease, the probability is that the boy would not have lived to his present age without some return of the same kind, but he has never since that period been similarly afflicted.

After the operation on the second eye, the pupils assumed their normal situation in the orbit; and his appearance is now such, that no ordinary observer would detect that he had ever suffered from strabismus.

From the want of a knowledge of these facts

many surgeons are misled in their early attempts to relieve strabismus, and erroneously consider the operation to be completed, when in reality it is only half performed; or when, perhaps, the tendon has not been even cut at all. While assisting others, I have frequently pointed out that the operation still required some further steps to render it perfect, and have usually been met by the observation, "that nothing further could possibly be requisite, as the tendon was clearly divided, and the patient possessed the power of turning the pupil outwards; the eye being straight, and in its proper position, when the other was covered over." The only conclusion to be drawn from this reasoning is, that the operator was not aware that the division of the tendon alone, in many cases, is insufficient to liberate the eye and remove the obliquity.

The oblique movements in the directions upwards and inwards, and downwards and inwards, are, by the unpractised operator, ascribed to sympathetic influence; being satisfied if his patient cannot conceal the pupil in the nasal canthus of the orbit in as great a degree as he could previously. Now, we have already seen that these *diagonal* movements do not proceed from morbid muscular action, but from the natural contractions of the superior, or inferior, rectus, whilst the eyeball still continues fettered by some portion of fibro-cellular attachment; and that, if this be divided, the operation will be complete.

TESTS BY WHICH TO DECIDE WHETHER THE OPERATION IS COMPLETELY PERFORMED.

The most decided test of a perfect separation of the tendon and adventitious adhesions, is not that "the eye can assume its proper position when its fellow is covered over, or that it can be directed outwards by an act of volition," but that there result from the operation a total inability to move the pupil *horizontally* inwards from the natural position that it ought to occupy in the visual axis of the orbit; and at the same time an incapacity of directing it, in the slightest degree, in either of the diagonal lines above indicated. When an attempt is made to look at the nose, if the operation be complete, the pupil, instead of being inverted, is depressed, the eyeball being drawn directly downwards by the action of the inferior rectus muscle.

If the above conditions be fulfilled,—*and they ought to be, provided the obliquity be confined to one eye, and the rectus muscle alone be concerned in its production,*—we may rest assured that the eyeball is completely liberated. But we cannot always obtain this decided result. It sometimes happens—indeed, nearly always, when *both* eyes are implicated—that the operation may have been as perfectly performed as it can be, in as far as the division of the adductor is concerned, and that still the patient has a slight cast when he looks

with both eyes at an object placed directly before him. This remaining power of inverting the pupil, there is reason to believe, proceeds from a concurrence of action of the inner fibres of the superior and inferior recti muscles, aided, we are told, in a few instances, by the superior oblique, which, when the squint has been considerable, and of long duration, it has been supposed, may likewise become involved in its production. Be it observed, however, that there is no occasion to divide these inner fibres, since, if there exist no *permanent* implication of the other eye, this remains of morbid action will generally cease in a day or two. But if any *confirmed* obliquity have been induced in the second eye, I have always found it best to operate on this organ, before dividing the inner fibres of either of the secondarily affected muscles; on doing this, every vestige of the original evil has, for the most part, either instantly ceased, or subsided in the course of a few days, never to return. It would appear, that this implication of the inner fibres of the superior and inferior recti muscles, just described, is generally very feeble, and in a great measure dependent on the sympathy that subsists between the two eyes, since it is in the greater number of instances only capable of being exerted so long as the tendon in the second eye continues undivided. When, on the contrary, the obliquity thus produced is remedied, by at once dividing the inner fibres of the superior or inferior recti muscles, as has been

recommended*, the eyeball is not only very prone to start forward, and impart an ungainly appearance to the individual, but the affection still continuing in the second eye, we are not the less obliged to operate on this organ afterwards; whereas, by operating on it first, we not only materially dimniish the risk of protrusion, but in general completely rectify both eyes; and should the eye first liberated have been a little enlarged by the operation, we have it very much in our power to make both correspond in this particular.

Mr. C. Guthrie, who cuts the muscle through, at a short distance (about half an inch) posterior to its insertion, and where it is partly fleshy, considers a small spurt of blood a satisfactory sign that the tendon is fully divided. But it would seem that a simple separation of the connection of the muscle with the sclerotica has not always been sufficient in his practice to remove the squint, and that he has occasionally met with the same adventitious difficulties to which I have so often adverted. After dividing the muscle, of which he is satisfied by the occurrence of the above indication, "the patient," he says, "should be desired to open the eye by raising the lid, and to turn the eye inwards. If he cannot do this, the operation has been completed; but if he can do it in the slightest degree, the muscle, or its *lateral cellular or tendinous attachments*, has

* Vide Lancet, July 18, 1840.

not been entirely divided, and the eye being again secured by the fore-finger or the elevator, the scissars are to be used, or the director is to be once more introduced, and the undivided part sought for and incised, when it will be found that the patient can no longer turn the eye inwards; and it is surprising how small a portion of attachment can do this, either on the under or upper part. In the earlier operations performed," he continues, "I was not aware of this circumstance, and in two cases in which a slight turning *inwards* re-appeared a fortnight after the operation, I attribute it to this portion of membrane, which in all probability adhered to the posterior end of the divided muscle. It may also effect this slight turn from its connection either with the rectus superior above, or the inferior below, as the case may be. In five of the cures performed, the eyes would not at first turn outwards, although the sclerotic coat was rendered distinct to all present, for nearly three-eighths of an inch every way—which, indeed, ought always to be done to ensure success in double cases—and it was only by dividing *the additional band of membrane or tendinous expansion* I have alluded to, in three cases upwards, and in two downwards, that the operations were perfectly completed *."

Another test that the operation has been thoroughly performed is the capability the patient

* Report laid before the Governors of the Charing-Cross Ophthalmic Hospital, by Charles Guthrie, Esq.

acquires of not only directing the pupil much more outwards than he could previously, but, if the tendon of the external rectus be free to act, of turning it much more outwards than natural. Even the decided indication already insisted on, viz. a total inability to move the pupil from the centre, between the angles of the orbit, horizontally towards the nasal canthus, may be frustrated by an adherent condition of the tendon, or by a partially paralytic state of the abductor muscle. A little experience, however, teaches the surgeon how to ascertain, by sweeping the sclerotica carefully with his blunt hook, when the liberation of the eye is complete, without being obliged to rely upon the foregoing investigation, although he should never neglect to institute it, as he is thereby generally enabled materially to corroborate his judgment.

AGE AT WHICH THE OPERATION SHOULD BE PERFORMED.

The operation may be undertaken at any age with advantage, but not always with an equal prospect of complete success. The youngest patient on whom I have operated was three years of age, and the oldest fifty-four. Of course, the younger the individual, the less probability there is of other muscles than the adductor being implicated,

and the less likelihood is there of the fascia being thickened, contracted, or morbidly adherent. At the same time, if we divide the tendon at a very early age (*i. e.* younger than I have stated), we run the risk of subjecting a case of simple spasmodic strabismus, arising from gastric irritation, and curable by more appropriate means, to an unnecessary operation. The disorder ought to have been confirmed, for at least a year or two, before surgical means are had recourse to; and as success is equally certain at any period during early life, there is no occasion to fear a failure by delaying the operation till we can fully satisfy ourselves that all other treatment would be of no avail.

When the deformity has existed for a number of years, we must not be too sanguine in our expectations of immediate, or complete success, as the morbid changes already detailed may have established themselves to an irremediable extent. Even under such circumstances, however, the patient may be always sufficiently improved to render it worth while to submit to the trifling pain, and temporary inconvenience, of the operation.

OF THE PROPRIETY OF OPERATING ON BOTH EYES.

For the most part, as has already been shewn, although there may apparently exist an equal de-

gree of obliquity in the axes of both eyes, it will, on a careful comparison of their capabilities, be found that the affection is much more marked in the one than in the other; and that, on dividing the tendon and liberating completely the globe of the most faulty eye, the axis of the other, though for a few hours at first often rendered more objectionable, will soon become correct, and continue so. The previous obliquity in such case had resulted simply from sympathy; or, to speak more correctly, from the constant co-operation that subsists between the two eyes in all their movements, in order to render vision with two organs a single function. I conceive it to be quite possible, although I have no positive proof on which to found my opinion, notwithstanding the statement of Buffon and others, that strabismus convergens may assail both eyes at the same time. It is evidently, at its commencement, in many instances, a spasmodic disorder, which attacks the internal rectus, and perhaps other muscles of the eye; and I can see no reason, although it may not be a usual law, why the corresponding muscles of each eye should not be simultaneously affected, especially when the distortion proceeds from functional derangement of the alimentary canal, or any other disorder capable of disturbing the nervous system generally. I have seen cases in which the internal recti have been simultaneously affected with paralysis*, to the exclusion

* Vide Figs. 1 and 2, Frontispiece.

of the other muscles of the eye; why, therefore, may they not both be attacked with spasm at the same time? The same argument will hold good in such cases of strabismus as arise primitively from an opposite cause; viz. partial loss of power in one or both of the external muscles.

Be this as it may, at all events it sometimes happens, when the defect is well marked, that the sympathetic influence it produces on the opposite eye, by long and active continuance, degenerates into a permanent shortening of the muscle, and a corresponding degree of contraction and thickening of the fascial and sub-muscular cellular tissue, similar in every respect to that of the primarily affected organ; so that it becomes requisite to liberate the secondarily distorted eye also. If we neglect to do this, in the course of time, when the muscle first divided has formed a re-union with the sclerotica, a relapse of the original deformity may be induced in the eye that had been the subject of operation.

From the facts detailed in the former parts of these observations (vide Case V.), it is evident that the second eye cannot be operated upon in all cases with impunity. We have seen that when the second eye is thoroughly liberated, the external recti are apt to assume an ascendancy of power; and, when the patient looks outwards, to draw the eye so much to the external angle of the orbit as to produce a very unpleasant leer, and at the same time to render vision double. But, so long, it would seem, as the motions of the eye

are restrained by any vestige of retaining power, or any bond of union is left between the tendon of the adductor of either side and the sclerotica, however slight it may be, this untoward event does not happen.

In order to meet this difficulty then, it occurred to me, in performing the second operation, that it might be possible to avoid destroying *completely* the physical restraint by which the eye is held in bondage, and thus preserve what appeared to be requisite to obviate the undue direction of the eye outwards, which, though perhaps trifling in degree when the organ is in a state of repose, may be very considerable when the individual looks at an object placed only a little to either side of him.* I found the experiment successful; and, out of a great number of cases operated upon with this precaution, I have never met with the same unfortunate consequences as those recorded, page 26, of the present remarks; although I have seen two other cases in which this precaution was neglected, and similar results supervened. When other muscles than the internal rectus are concerned in producing the squint, the eye will not turn out when the adductor is divided.

In operating on the second eye then, under such circumstances, the great secret, by which alone a fortunate and satisfactory result can be secured, is to avoid liberating the eye completely. If this be done, we shall find that the action of the

* Vide Plates IV. and V.

abductor, which might otherwise have turned the pupil outwards, will just be sufficient to draw it to the axis of the orbit; and, in all the consentaneous movements of the eye, the desired unity of action, and the necessary correspondence in the axes of the two organs, will be maintained. When the inner fibres of the superior or inferior recti, or either of the obliques—if these muscles ever participate in the production of strabismus—seem to be implicated—and of this we can easily judge by the eye first subjected to operation not being perfectly restored to its proper site, when completely liberated at its inner aspect—no such precaution is necessary; and even when it is practised, the restraint that is left should be as *slight as possible.* It is true that in such cases we do not always succeed in placing the pupils exactly in the visual axis, but we restore them so nearly to that point, that the trifling cast which remains is scarcely worthy of notice: and it is certainly better that the operation should be thus slightly imperfect, than that one or both pupils should be unduly everted, and vision be ever after double; unless the patient be subjected to the uncertainty of a second series of operations on the external recti muscles.

PATHOLOGY OF STRABISMUS CONVERGENS.

From what has already been stated in various parts of the present observations, very little remains to be said on this head. The views that I entertain must ere this be familiar to my readers; still it will be requisite to recapitulate them, in order to notice those of others, and to enable us better to understand the next part of our inquiry, viz. the *causes of relapse.*

From whatever remote causes the disorder may proceed, and these are numerous, being both functional and organic, the first immediate step towards the production of strabismus is either spasmodic contraction, more or less permanent, of the adductor, or loss of power in the abductor muscle. I have not met with a single case of congenital strabismus, though, in many instances, the deformity has been reported to have supervened within a few days after birth. "Even children of parents who are affected with strabismus, and in whom we might conclude it would be hereditary, do not exhibit any appearance of the deformity for months or perhaps years after birth."—*(Op. cit.)*

When spasm of the inner muscle is the immediate cause of the affection, I do not apprehend that this condition of the part is, at first, by any means necessarily permanent, though it would seem that it may very soon become so. Whilst the distortion remains purely spasmodic in its

nature, "the motions of the eye may be perfect, except on certain occasions of excitement, or of disorder, or of intense application, or of employment of the eye: the strabismus then becomes apparent, and the eyeball is obviously drawn in one particular direction."—(Dr. Marshall Hall's Lectures on Diseases of the Nervous System.) In proportion as this spasmodic condition of the adductor assumes a less intermittent character, the muscle becomes permanently shortened; and although capable of a certain degree of extension when the antagonist abductor acts, it still retains the eye turned somewhat inwards when the organ is quiescent.

Should any inflammatory affection of the membranes of the eye supervene during the existence of a spasmodic state of contraction of the adductor, the sub-muscular cellular tissue, as well as the general fascia which sheathes or incloses and unites the muscles, is liable to be not only thickened, but rendered unyielding and adherent. When this change is established in the investing membranes, even should the spasmodic condition of the muscle cease, the tendon will, of course, remain closely confined, or attached to the sclerotica, and be unable to resume its normal condition and natural functions.

During the progress of this alteration in the character of the fascia and sub-muscular cellular tissue, as the eye is necessarily in motion—the opposite abductor being constantly called into action — any adventitious adhesions that take

place between the sclerotica and the tendon, of the adductor, and that would otherwise immoveably fix the eye in the inner canthus, become gradually elongated into bands, in the same manner as the adhesions which take place between the pleuræ, after pleuritis, become elongated by the constant action of the chest during respiration; or like those, often met with, which unite the heart to the pericardium, and are the result of pericarditis. Now, it is either this morbid condition of the investing tissues, the contracted state of the fascial covering, or these bands of fibro-cellular connection passing between the sclerotic tunic and the under surface of the muscle and its sheath, that in such numerous instances retain the eye in an abnormal position after the tendon has been divided, and render so many cases only partially successful. I have met with these obstacles very frequently; and in two cases found the investing membranes almost cartilaginous, and so contracted and unyielding that the patients were wholly unable to move the pupil out of the inner canthus previous to operation. When a case of this description presents itself, we find that, after dividing the tendon, the pupil still turns very much inwards when the eye is quiescent, and that when the patient makes an effort to cause the two eyes to converge still further, by directing them towards the inner canthus of each orbit, being deprived of this power, by the division of the tendon, the effort is aided by the united action of the

inner fibres of the superior or inferior recti, and the pupil is in consequence drawn either diagonally upwards and inwards, or obliquely downwards and inwards; the direction which the eye takes in this respect depending on the comparative influence of these muscles, and the site of the retaining force. The separation of the investing membranes from the eyeball under such circumstances, if this can be done with safety, is essential to the completion of the operation.

We are not, however, always to expect to find a fibrous interlacing of adhesions such as I have just described, since this is the result of inflammation, and only to be met with in certain cases that have suffered from ophthalmia after the supervention of strabismus. In most instances the contracted tendon is all that requires division; but should we find the contrary, if the individual has never suffered from inflammation, a little examination with the hook will in general detect only a thickened and contracted condition of the submuscular fascia and cellular tissue: this change in these textures having gradually supervened in order to accommodate them to the shortened state of the muscle and its tendon, and the new position of the eyeball. When any of the morbid alterations of texture just described are fairly established, we may rely on it that nothing short of a complete dissection will effectually liberate the eye from bondage.

That other operators have met with the same pathological changes, is not only clear from the

passage already quoted from Mr. C. Guthrie's report (p. 48), but may be gathered from the following remarks of Dr. Franz and Mr. Lucas, although these gentlemen do not take precisely the same view of their causes as I have entertained:—

"The muscle," says Dr. Franz, "was found atrophied in but few instances: in some it was hypertrophied; and in many its *attachments were irregular, bundles of muscular fibres being inserted to the sclerotica behind the proper tendon, or this expanded to a greater or less extent upwards or downwards.*" *

The following quotation from Mr. Bennett Lucas's "Practical Treatise on the Cure of Strabismus," p. 26, is also confirmatory of the foregoing pathology, and of the opinion I entertain, that division of the tendon is, in many cases, only a small part of the operation:—

"The sub-muscular fascia," observes Mr. Lucas, "like the sub-conjunctival, passes also from one muscle to another, and forms a strong continuous double circular membrane behind them, the masses of fat, enveloped with their own proper cells, being placed between its layers.

"It also affords considerable resistance to the passage of an instrument beneath the tendons of the muscles, and, in operating upon them, requires to be fairly divided.

"In the eyes of young subjects, I have never

* Medical Gazette, October 2, 1840.

found either the subconjunctival or the submuscular fascia as strongly developed as in the adult; and in this they resemble the tunica sclerotica and the muscles themselves.

"The degree of development of both these fasciæ, in some cases upon which I operated for the division of the internal rectus muscle, was very great, and *was quite sufficient, after the muscle was fairly divided, to give the eye an inclination inwards; when I divided this tense structure the eyes became perfectly straight.* Contractions of other fasciæ of the human body, as the plantar and palmar, are so frequent as constantly to call for operation; and the development and contracted state of the subconjunctival and submuscular fasciæ resemble these, and require careful examination *before the surgeon pronounces that he has succeeded in curing a squint, after he has divided the tendon of the muscle.*"

And again he observes (page 28), "When the muscle is unnaturally developed, the operator should be prepared for a good deal of hemorrhage upon its section being made, say from ten to twenty drops; *but what is of greater practical importance to remember is, that it is in those cases where the muscle is in this state that it forms strong adhesions to the sclerotic coat of the eye, and at the end of ten or twelve days gives the organ an inclination inwards, varying more or less in degree, but never to the same extent as before the operation.*"

The existence of morbid adhesions between

the muscle and the sclerotica, in a vast number of instances, I believe to be the true pathology in the advanced stages of the disorder, from having so frequently encountered the obstacles just related, and been unable to detect them in the sound and dead eye. When we carefully examine the submuscular cellular tissue in the recent subject, if no strabismus existed during the lifetime of the individual, we find it to be so extremely delicate and yielding, as to convince us that it must undergo the changes here adverted to, otherwise it could never offer the resistance it often presents to the completion of the operation. Mr. Hocken, in some useful remarks on strabismus (published in the Medical Gazette, for September 11, 1840), has stated it as his opinion, (but which, in fact, was previously maintained by Mr. Lucas), that strabismus often arises from hypertrophy of the adductor muscle, aided, perhaps, by atrophy of the abductor. Now, I am not prepared to assert that such a change in the development of the muscles of the eye never exists, though I do not believe it to be by any means a frequent condition of the inner muscle in cases of this description, nor do I see how we could very easily detect it even if it were. I can readily imagine, with Mr. H., that an increase of nervous influence, followed by hypertrophy, might attend the excessive employment of any of the orbital muscles, whilst their antagonists, on the other hand, might become atrophied from disease; and that, in this manner, it would be easy

to account for strabismus originating in imitation, (if it ever does arise from this cause), habit, improper education of the eyes, long retention of the head in one position, disparity of vision, opacities of the cornea, &c. &c.

But we find, from the general history of the disorder, that in the vast majority of examples the obliquity invades suddenly, before any change such as hypertrophy can possibly have been established. In some cases the disorder is intermittent, and gradually becomes permanent; in others it would appear to be confirmed from the first. Were simple hypertrophy of the muscle the common cause, then cutting the muscle across would, in every such case, liberate the eye; but those who operate extensively will find this far from being the case. Severing the muscle, in a great many instances, is only a small part of the operation.

Want of attention to this fact, I repeat, is the main reason why we see so many persons only partially relieved.

If the fascial bands, to which I have so often alluded, or the adhesions just adverted to, be left undetached, they form the ground-work of a relapse of the distortion, by detaining the globe still fettered, until the cut tendon has time to form a new union with the sclerotica.

Mr. Guthrie, in the last edition of his Report, already quoted, is of opinion that, in certain cases, the external rectus muscle may be in a similar semi-paralytic condition to that which occurs

in the internal rectus, when the eye is affected with the divergent modification of the deformity we are considering; and that the natural efforts of the latter muscle, in such instance, are sufficient to invert the eyeball:—"Strabismus," says he, "is usually supposed to depend immediately on a too powerful action or contraction of the muscle of the side towards which the eye turns: inversion, for instance, on an augmented action with increase of size of the internal rectus muscle, and eversion, on a similar increase of power in the external rectus muscle; but I have reason to believe that this is certainly not always the case, and analogy — I may now say experience — renders it extremely doubtful in the greater number of instances.

When the mouth is drawn to one side, as it frequently is, in consequence of defective power in the portio dura of the seventh pair of nerves supplying the muscles of one side of the face, the side really affected is perfectly quiescent, and nearly motionless, and the deformity takes place on the sound side, in consequence of the muscles acting, whilst those on the other offer no opposition. They have ceased to be antagonists; and when these persons laugh, the mouth goes to the sound side, because the muscles of the affected side do nothing, instead of taking an equal share in the process, and widening the mouth from ear to ear.

In the complaint called wry-neck it is different, and occurring, for the most part, from a different cause. The sterno-cleido-mastoideus, the great

muscle on the side of the neck, may be felt to be thickened, hardened, and contracted, and the division of it relieves the part and effects a cure.

In the operation for squinting, the muscle divided does not usually appear to be diseased, but, on the contrary, to be quite in its natural state; giving rise to the belief that it is not in fault, and that the defect has taken place in these instances in its antagonist muscle, in the same way as it occurs in the case of paralysis of one side of the face; and I am quite satisfied that this is the case in the greater number of instances."

Although not the true rationale of strabismus in all cases, there can be no doubt that the view entertained by Mr. Guthrie is applicable in many instances. Slight paralysis of the external rectus muscle, I believe, often precedes the other morbid changes which we have seen may supervene after the distortion has existed for a length of time. In the majority of examples that present themselves we find that the affection has, in the first instance, been connected with cerebral disorder, indicated by general convulsions; and although the adductor, as well as the other orbital muscles, as every practitioner may have frequently witnessed, may participate in the spasmodic affection, and be afterwards restored to a natural condition—especially when the brain and nervous system have been only sympathetically implicated—yet it very frequently happens that the spasmodic condition of the internal rectus returns from time to time, and finally becomes permanent. Should any

lesion of structure in the brain or nervous system have resulted from the general attack, then it is equally possible that the consequence may be paralysis, more or less perfect, of the abductor muscle, when similar distortion of the eyeball would supervene, although proceeding from a totally opposite condition of the moving powers. Hence, then, there would appear to be two important primitive conditions of the orbital muscular system that may equally prove the source of strabismus. I am, moreover, further inclined to espouse this doctrine from having satisfied myself by experiment on animals — vide Appendix — that when all the orbital muscles are in a healthy condition, the natural tendency of the external rectus is to contract when its antagonist internal muscle is divided, and *vice versâ;* and to such an extent as to produce divergent, or convergent strabismus, as the case may be.

But although the external rectus muscle may be affected with paralysis, and the eyeball be subject to the unopposed contractions of its opponent, that is no reason why permanent shortening of the adductor, and the general adaptation of the fascial and other textures, should not subsequently supervene, and still more radically rivet the disorder; especially when strumous or other deep-seated inflammation invades the membranous parts of the eyeball, and terminates in uniting them by adhesive deposit.

Mr. Guthrie's theory affords a very reasonable explanation why, when none of the organic

changes alluded to are established, the pupil does not always turn unduly outwards, as in animals, after the division of the tendon of the adductor; while the opposite doctrine, *cæteris paribus*, will enable us to explain why the contrary, viz. undue eversion of the pupil, should occasionally render our operation a mere substitution of one evil for another. If these views be correct, we perceive the vast importance of ascertaining, in every possible manner, the history of the deformity before operating, that we may be the better prepared to guard against an unpropitious result, which, as I have shewn in treating of the propriety of operating on both eyes, there is reason to believe may often be both foreseen and prevented.

CAUSES OF RELAPSE.

A sufficient length of time has not elapsed since the cure of strabismus by surgical means has been practised, to enable us to estimate the proportion of permanent success with which it is likely to be attended. When the operation is thoroughly performed, and only one eye has been originally affected, there does not appear much probability of any renewal of the disorder. The morbid consentaneous influence, that might in the course of time have involved the second eye, being no longer in operation, the temporary obliquity

it derived from this source soon subsides, and both eyes remain sound; but if it should be found that both eyes were primitively affected by the same exciting cause, or that the disorder which was at first sympathetic in the second eye, has become permanent, then it is possible, even after operation, when a reunion has taken place between the divided ends of the tendon and the sclerotic coat, that the eye which was the subject of operation may in turn become again sympathetically implicated; though I should imagine never to so great an extent as previously. Relapse, then, being evidently dependent on the circumstance of both eyes having become permanently affected previous to operation, the proclivity to this event will of course be in proportion to the degree in which the unliberated eye remains implicated.

Relapse, from the tendon re-uniting itself too far forward on the sclerotica, is a very rare occurrence, as the muscle retracts instantly on being cut, and the eyeball rolls outwards; thus in a twofold manner increasing the distance betwixt the severed part and its old insertion. This occurrence may also in general be prevented, by making the patient use the eye that has been operated upon as soon as ever it can bear exposure to the light; at the same time securing its full eversion by binding up the sound organ.

Even although no union were ever to take place between the divided muscle and globe of the eye, still I conceive it quite possible that the superior and inferior recti, if not previously implicated,

might gradually become involved, and, by the force of involuntary practice, ultimately so accommodate themselves as to perform functions for which they were not originally destined.

Another source of relapse, of a much more simple nature, though by no means of frequent occurrence, is the contraction of the new or substituted parts of the inner canthus of the eye during cicatrization, when the conjunctival folds and loose cellular tissue have been unnecessarily removed. I have remedied two relapses of this description, by again freely dividing the cicatrices: the eye was, in each case, instantly restored to its proper situation.

The possibility of cicatrization again limiting the movements of the eye, though a rare occurrence, is another, but, perhaps, as it can be easily obviated, a trifling objection to unnecessarily destroying any of the outer coverings or appendages of the eye.

When strabismus arises from any defect of vision in one eye, or from a disparity in the focus of the two organs, and the distortion has been produced by the efforts of the patient to accommodate the faulty axis of the imperfect eye, we may expect—as the strabismus is in such case a resource of nature to obviate the difficulty, as soon as re-union takes place between the divided tendon and the sclerotica, and the muscle is again free to act—that the original efforts will be renewed, and the obliquity recur. For the most part, as has already been so frequently insisted

on, strabismus is the cause, not the source, of defective vision, and on its removal the sight improves. When, therefore, we find the converse of this fact, and the patient complains that his vision has, in consequence of the operation, become more confused, we have reason to apprehend—if the previous history of the case confirm the opinion — that we have operated on an example of the above description, and that a relapse may ultimately occur.

When the affection proceeds from any disparity in the focus of the two eyes, we may presume that it will come on slowly, and that the eyes will be a considerable time in attaining their utmost degree of obliquity. We may also expect to find on inquiry, if it have supervened at an age when the individual was capable of judging for himself, that the sight has gradually improved in proportion as the distortion became more manifest; whereas the reverse is the usual order of events when squinting proceeds from any of the more common causes. Now, it is of importance to attend to this diagnosis, inasmuch as it would be injudicious to operate on a case of strabismus proceeding from such a source.

Fortunately, however, under either of the foregoing circumstances, on the re-establishment of strabismus, it is highly probable that vision would be restored to its former condition. Inquiries, then, with a view to ascertain the relation subsisting between the deformity and the defect in vision, especially as regards the order of their respective

occurrence, should be very carefully instituted before the operation be recommended. In fact, the proclivity to relapse will very much depend, in numerous instances, on the nature of the remote cause, and on the probability of the persistence of this after the eye has been set at liberty. From what I have seen, however, I do not imagine that relapses will be of frequent occurrence; on the contrary, I am of opinion that they will be very rare. Several cases of alleged relapse that have been shewn to me, were not returns of the affection, but only imperfectly performed operations, or the result of mere sympathetic connection with the other eye, which also, in such case, is always more or less affected. A few of these cases I have myself since remedied by operating on the second eye, which had erroneously been regarded as not implicated, on the principle that "squinting never affects both eyes simultaneously."

A fortnight or three weeks, however, should be allowed to elapse between the operations, not only to afford the eye, presumed to be unaffected, the opportunity of correcting its obliquity, and thus to satisfactorily decide the question whether it be itself really implicated or not; but also to enable the muscle, first divided, to form a new insertion into the sclerotica. If this latter precaution be not attended to, it will be found that one or both eyes may suddenly turn morbidly outwards when the adductors are called into contraction. During the interval between the two operations, as soon as ever the patient can bear to use his eye, and this he can

generally do within a few hours after the tendon has been divided, it is desirable to place a soft compress of lint and a bandage over the other eye, to prevent its morbid movements from influencing the one that has been the subject of operation. If we neglect this precaution, it is possible that the divided tendon may form a second attachment too near its former insertion, the eye being inclined unduly inwards during this period. When the intact eye, however, is covered over in the manner suggested, the one that has been liberated preserves its proper position in the axis of the orbit, so that the reunion between the cut tendon and sclerotic tunic takes place considerably posterior to the original site; as the muscle, it may be presumed, shrinks in some degree when set at liberty.

ON THE OPERATION FOR STRABISMUS CONVERGENS.

The operation I perform is that suggested by Mr. Bennett Lucas, which I believe to be infinitely the best in every respect.

Having decided on which eye to operate, it is of advantage to steady the other previously. The patient is therefore desired to close his eyelids; a soft compress of lint is then to be bound over the sound organ, so as to press gently on the globe, and constrain its movements.

Fig. 1.

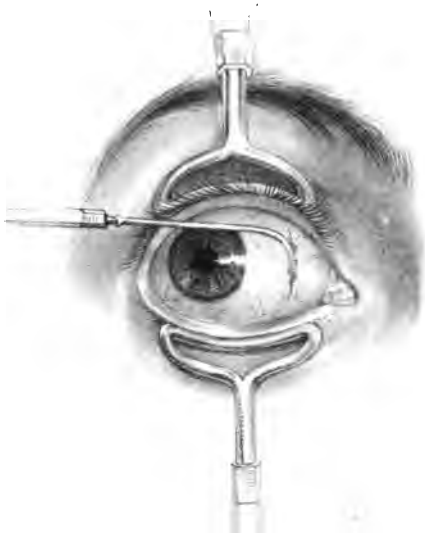
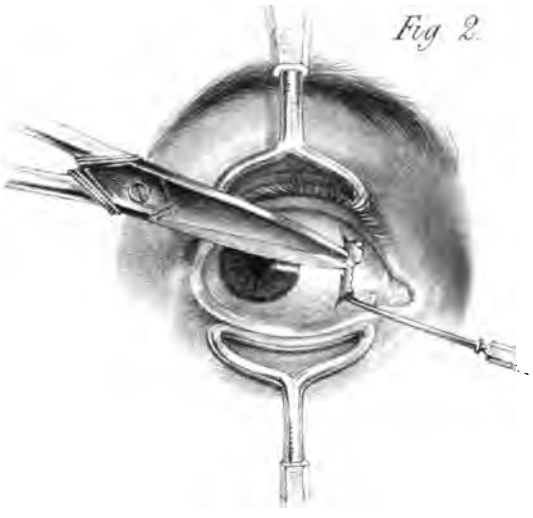


Fig. 2.



Drawn from Nature on Stone by W. BAGG. Printed by C. Hullmandel

Dr.

In grown persons it is not in general requisite to employ any instrument to keep the eyelids open; the fingers of an assistant are sufficient: but in children some mechanical contrivance for this purpose is usually necessary; and even in adults, if the parties do not object to it, we shall find such an assistance to be in general better than the fingers. The instrument I employ is the double speculum proposed by my friend Mr. John Northon Thompson, of Nottingham, and which, with his permission, is here represented.*

It is the best instrument of the kind I have seen, and has the advantage of enabling us to hold the eyelids open in spite of every spasmodic effort to close them, *without creating any pain,* or even occasioning uneasiness to the patient. It has the further advantage of enabling us to get at the eye freely, the hands of the assistant being very far removed from the site of the operation. I cannot imagine the necessity of putting the patient to the suffering of depressing the lower eyelid by means of artery forceps, as recommended by some surgeons; neither have I ever found it necessary to fix the globe of the eye by means of a sharp hook.

* This speculum, as well as the other instruments in general use for the performance of this operation, may now be procured at almost any surgical instrument maker's. But, for neatness of finish, and accuracy of construction, I give the preference to those made by Mr. Weedon, Hart Street, Bloomsbury.

The patient being placed on a chair with his face turned obliquely to the light, and the back of his head leaning against an assistant, is desired to direct his eye outwards; the conjunctiva is next to be pinched up by means of a fine forceps, and cut across *vertically* with a pair of strong scissars, nearly midway between the edge of the cornea and the semilunar fold of the membrane. Previously, however, to snipping it, we should touch the eye a time or two with the flat side of the forceps, so as to habituate the membrane to the contact of a foreign body, and prevent the patient from starting. The opening through the outer coverings should be made freely, and care taken in making it completely to divide the subconjunctival loose cellular tissue, so as to fairly expose the tendon from its upper to its lower margin. We may then sponge the part, should it be obscured with blood. *

The blunt hook is then to be inserted under *the tendon*, so that, when this latter is raised and drawn to the external opening, a small portion may be snipped out of it. Should the pupil, when this is done, be found not to occupy its proper situation, the hook should be again introduced, and any bands of fascial or fibro-cellular tissue,

* As touching the irritable conjunctiva is productive of pain or uneasiness, and causes the patient to wince, I use small pieces of fine sponge, cut into a conical form, the point of which alone is applied to the bleeding part, and can be insinuated into the inner canthus of the eye better than if it were irregularly shaped.

that still fix the eyeball, should be brought to the external opening in the same manner as the tendon has been, and then divided; this being repeated till the eye is perfectly liberated.

The only point in the operation that requires more precise instructions is the direction in which the blunt ~~point~~ hook should be introduced, and the manner in which it should be made to gently sweep the sclerotica in search of condensed cellular tissue, contracted fascia, or morbid adhesions. This is the grand step, in which most surgeons, in their early operations, fail. They generally introduce the hook by holding it at a right angle with the eye, its concavity looking upwards, and thus almost invariably miss inserting it under the tendon; whereas, if it be introduced by holding it almost parallel with the eye, the point being directed downwards, as represented in the engraving (Fig. 1), until it reach the inferior margin of the tendon, and then the handle be turned carefully upon its axis, and the hook next gently swept over that portion of the sclerotica which it is necessary to clear, no difficulty will ever be experienced in passing it under the tendon, or any thing else that it may be requisite to divide. After its point is turned upwards, all that requires attention is to keep the flat side of the instrument towards the eyeball*, and its ex-

* The hook that I use is flat, and similar, in general construction, to that recommended by Mr. Lucas, but somewhat larger in the curve.

tremity in gentle contact with the sclerotica, taking care to make it emerge through the external wound, by keeping the handle well depressed, and causing it obliquely to cross the nose. (Vide Fig. 2.) I have seen a great many operators at first thrust the extremity of the hook directly against the globe of the eye; and some, I am informed, have actually pushed it through the sclerotic coat, and allowed the humors to escape; while almost every one, from want of attention to the last direction, that of making the handle obliquely to cross the nose, catches its extremity under the superior tarsal cartilage, from whence, only after numerous ineffectual efforts, they finally disentangle it.

TREATMENT AFTER THE OPERATION.

If the operation be performed neatly, and with address, no more of the conjunctiva being cut or displaced than is necessary for the purpose of dividing the tendon, little or nothing requires to be done afterwards. A fold or two of lint, moistened with cold water, may be applied over the closed eyelid, and retained there for a few hours, to obviate as much as possible ecchymosis, and prevent inflammation; which latter, however, very rarely

supervenes. Out of very nearly five hundred cases that have come under my cognizance, performed after the manner just described, in only two instances has the application of leeches been required. The ecchymosis is sometimes considerable, especially if the conjunctival tunic have been unnecessarily raised, so as to allow of infiltration of blood under it. Should the eye become painful in the course of the day, the patient may be desired to foment it with warm water, or to use a decoction of chamomile flowers, or bruised poppies. On the second day we shall find a considerable deposition of lymph from the subconjunctival membrane uniting the cut edges of the conjunctiva, and be led, perhaps, from its abundance, to expect that a tumefied cicatrix will result; but such is seldom the case. In the course of a short time this deposition gradually disappears, and along with it the ecchymosis.

In order to hasten both these results, we may recommend, after the third or fourth day, a slightly astringent or stimulating solution to be dropped into the eye twice or thrice a day. From one to two grains of sulph. zinci, dissolved in an ounce of rose water, answers very well for this purpose.

When any portion of the conjunctiva has been inadvertently cut away, the reparative process is often very tedious, and the cicatrization is retarded by the exuberant growth of mushroom-like granulations. These may be repressed by the daily use of sulphate of copper, or, what is much better,

and far less painful, we may allow them to grow till they are large enough to be cut away, and then remove them by means of fine forceps and scissars. They often bleed freely, but their removal, as they are very insensible, is unattended with pain. I used to apply the sulphas cupri to hasten the disappearance of the reparative lymph, but I found that the irritation it created kept up the turgescence of the blood-vessels, and rather retarded than hastened the desired absorption.

The majority of cases are perfectly cured by the foregoing plan of treatment in the course of a fortnight or three weeks; and, during this period, they scarcely ever suffer any inconvenience beyond that which arises from ecchymosis, the eye looking blood-shot, turgid, and glistening.

Very often during the performance of the operation, whilst the tendon is being divided, the patient complains of pain in the forehead, described as being similar in degree and kind to what might be produced by pressing the finger very firmly on the part. This uneasiness sometimes remains for several hours afterwards, and is best relieved by warm anodyne fomentations to the eye.

In a few instances I have found the cerebral irritation, induced by the operation, excite the same sort of sympathy in the stomach that so frequently supervenes after couching; the patient being troubled with vomiting for several hours after the division of the tendon. When this symptom happens, we generally find, on

inquiry, that the patient has experienced similar attacks of vomiting from trifling causes on former occasions, or has been, at times, the victim of the ordinary forms of hysteria. Under these circumstances effervescing salines, or opiates, may be tried, but they have not, in my practice, been of much use. The latter remedy has generally aggravated the distress, by occasioning vertigo or headache, without relieving the symptoms for which it was administered. Indeed, temporary confusion, or giddiness of a few hours' duration, is no uncommon occurrence after the operation, without the assistance of a narcotic. Time and tranquillity appear to me to be the best remedies; these annoying symptoms usually ceasing after the first sound sleep, and being, in the meantime, much mitigated by keeping the patient quiet, and in a dark room.

Should membranous inflammation supervene, it must, of course, be treated by blood-letting, leeches, warm fomentations, active purgatives, and the other ordinary means, appropriate in simple inflammation of the textures affected.

STRABISMUS DIVERGENS (EXTERNAL SQUINT).

This affection is of much less frequent occurrence than the ordinary squint, strabismus *con-*

vergens. Out of nearly 500 cases of strabismus that I have examined, I have only met with twenty-three examples*; and of the operations performed upon these, very few have been, strictly speaking, *perfectly* successful, although they have nearly all been improved in a considerable degree. The external cast, strabismus divergens, was at first supposed to proceed from a similar cause, and to be analogous in its nature to the more common squint, strabismus convergens; but in many respects it differs from the latter affection materially, both as regards its pathology, and, as just stated, in the degree of success that attends the operation.

The intimate pathology of the affection still remains a mystery: there are certains facts, however, deserving of notice, that throw some light upon it, and at once point out that a remarkable difference exists between the two diseases in relation to their proximate cause. These I shall state, and leave it to physiologists hereafter to explain them.

A person affected with ordinary *convergent* strabismus, provided the eyes be not restricted in their movements by adventitious adhesions, or by a thickened and contracted state of the submuscular structures, can in general turn his eyes in any

* In Mr. Guthrie's Report, he informs us that eversion occurred seven times in 150 cases, which seems to average about the same proportion as observed by myself.

direction he chooses, by an effort of the will, and to pretty nearly the natural extent; while a person affected with *divergent* strabismus is, for the most part, limited in this respect. He can direct either eye outwards in looking at an object placed at the side of him, while *the opposite eye turns inwards to the full natural extent; but he is incapable of directing both eyes inwards simultaneously.* This even a person whose eyes are not deformed can with difficulty accomplish to any great extent, but every one can cause his eyes to simultaneously converge towards the inner angles of their respective orbits in a trifling degree. Why, then, in divergent strabismus, if the individual possess the power of the *adductors* separately, so as to make the axes of the two eyes, when turned to either side, correspond in the fullest extent, should the patient not be able to call the adductors into simultaneous contraction, and make the pupils converge in some slight degree towards the respective nasal canthus of each orbit? He has power, when he makes this effort, only over the undistorted eye: the pupil of the other does not pass the axis of the orbit. It is evident that each adductor is capable of the fullest degree of contraction, since each can act in concert with the abductor of the opposite eye respectively to any natural extent; why, then, should they be unable to act together? This is a curious circumstance, and can only be explained by admitting that the two adductors have lost that

sympathetic or consentaneous * power which enabled them to contract together; the loss of which power, it may be presumed, allows the external rectus of the faulty side to turn the globe of the eye outwards, and produce the distortion. But a circumstance that renders this phenomenon still more remarkable is, that such is precisely the power that persons possess over their eyes who have had one or both successfully operated upon, a sufficient time having elapsed to admit of a reunion of the divided tendon to the sclerotica: they can then turn either eye completely to the nasal canthus, while its fellow is directed outwards, but theycannot turn both inwards together.

When a person, who has had the muscle of only one side divided, attempts to cause the pupils to approximate each other, his power is limited to the intact eye. If the adductor tendons of both organs have been separated, then neither pupil can be drawn (unless in a very slight degree) beyond the axis of the orbit in a *horizontal* line, unless vision be directed to an object placed at one side, so that the internal rectus of the one eye may act in concert with the external muscle of the other; but both can be made to incline *slightly* inwards and downwards: this movement, however, arises from the contraction of the inner fibres of the inferior

* I denominate it *sympathetic*, because it is clear that if the adductors can, under any circumstances, turn the eyes *thoroughly* to the nasal canthus, they have not lost their *absolute* power of contraction.

rectus, and not from that of the adductor muscle. A person affected with *complete* paralysis of the adductors, as I have ascertained by examination of three patients so afflicted, and already alluded to, has no power over the muscle of either side, whether the effort to exert it be made conjointly with its fellow, or in conjunction with the abductor, with which each respectively co-operates in performing the simultaneous lateral movements of the eye.

The fact that *complete* paralysis can occur in one or both of the adductors, to the exclusion of the other muscles of the eye, tends to throw considerable light on the pathology of strabismus divergens. Out of the cases I have examined, three have been decidedly of this description, being complicated more or less with other symptoms of cerebral disease, and paraplegic loss of muscular power. Hence I am disposed to conclude that the more common proximate cause of external strabismus is a partially paralytic condition of the adductor muscle, by which the natural power of the abductor becomes comparatively excessive, and sufficient to draw the eye outwards. Another circumstance that leads me to regard loss of power of some description in the adductor as the immediate cause of this affection, is, that we so frequently find the distorted eye large (*i. e.* protruding) in comparison of its fellow—a condition which we now know to be a common result of enfeebling the retaining powers.

Whether divergent strabismus ever proceeds primitively from spasm of the external rectus, terminating in permanent shortening of that muscle, as there is reason, we have seen, to believe is frequently the cause of the convergent variety when it arises from gastric irritation, chorea, and certain other disorders, I am not prepared to offer an opinion. One case has presented itself to my notice that appeared to render this view probable. It differed from every other I had examined in respect to the degree of power possessed by the orbital muscles, though there was still a sluggishness in the motions of the eye, indicative of impaired nervous energy, that threw great doubt on the nature of the case.

When the external rectus is cut across, we do not find the eye instantly start into its proper position, as it does when the internal muscle is divided. The pupil goes more gradually to the axis of the orbit, as if it were not drawn there by an active force, but went there because the restraining power no longer opposed the movement. It requires, indeed, several days, in some instances, before it is reinstated. After the operation, moreover, the capability of moving the eyes towards the nasal canthus, by an effort of the will, remains precisely the same as before. Nothing has been gained in this respect; the patient has not acquired the power of directing both eyes inwards simultaneously. In fact, all the apparent advantage

obtained is that, when quiescent, the pupils of both eyes occupy the visual axis of their respective orbits, instead of only one doing so, while the other is directed outwards. The appearance of the patient in this respect may certainly be much improved, but, to counterbalance this, it is very probable that in some instances the eye, in consequence of its retaining powers being still further weakened, may protrude, and look perhaps more ungainly than when the internal rectus has been the subject of operation, and is followed by the same result. It is, therefore, a matter for consideration, to be determined by further practical experience, whether the division of the external rectus is a measure to be generally advised or not. From the few cases of divergent strabismus that have come under my notice, it appears to me that, in every instance in which the adductors are not *completely* paralysed, the operation is worthy of trial. It is by no means a severe measure, and is attended with very trifling subsequent inconvenience. Even when unsuccessful, with the exception of the contingent hazard above suggested, it is not productive of any results calculated to render the condition of the patient worse than before.

When the adductors are *completely* paralysed, as has been explained, the individual loses all power over them, and cannot, by any combination of action in the orbital muscles, cause the pupils to converge beyond the visual axes of the

orbits. In most instances, moreover, it is probable that there will exist some other indication of paralysis; such as ptosis, loss of power in the facial muscles of one side, impaired utterance, or even decided hemiplegia. At least such was the case in the examples to which I have already alluded.

Of the precise nature of the loss of power in the internal muscle I confess myself unable to offer any satisfactory exposition; at least none that will explain how this muscle retains its contractility to the fullest extent so long as it acts in harmony with the abductor of the opposite eye, and ceases to possess this power when called upon to act in conjunction with its fellow. The third and the sixth nerve, it would seem, can act together, but not the two third nerves. The sympathy that ought to subsist between them is in abeyance.

The divergent form of strabismus is more frequently confined to one eye than the convergent affection; still, as exemplified in the illustration selected for the frontispiece of the present Observations (Figs. 1. and 2), it may occur in both organs at the same time, but seldom in an equal degree. When the patient looks at an object placed before him, in such case one pupil, that of the eye least affected, is brought into the visual axis of the orbit, while the other remains everted. The sight, especially of the most distorted eye, is in general very imperfect; indeed, in some instances, it is absolutely amaurotic. Nor is it,

as in the convergent variety, improved, even in the slightest degree, by the operation; the loss of vision being in general coeval with the supervention of the strabismus, and dependent, in all probability, on pressure on the optic nerve or retina, or, in some instances, on organic cerebral disease.

THE OPERATION.

The operation of dividing the external rectus resembles, in most particulars, that of the section of its antagonist muscle, but is much easier of execution.

The patient being seated in a chair of convenient height—so placed that the light may fall directly upon the site of operation—is desired to direct his eyes so as to invert, as much as possible, the pupil of that the tendon of which is to be divided. It is unnecessary to apply a compress and bandage over the unaffected eye, as was recommended in treating of the division of the adductor, since the patient, when he makes an effort to invert the distorted organ, can do so in a much greater degree when the eyes move in unison, than when the sound one is prevented diverging from its central position. A fold of conjunctiva is then to be raised by means of a fine forceps, and freely divided, either with a pair of

knife-edged scissars, or by passing a fine sharp-pointed bistoury through it. Having thus exposed the tendon in its full breadth, we may either raise it by means of the flat blunt hook, or, what is preferable in this case, from the facility with which it may be accomplished, we may insert a fine probe-pointed bistoury underneath, and then, by withdrawing the instrument, complete the necessary section of the part. The point at which the tendon should be divided is situate about midway between the margin of the cornea and the fold of conjunctiva reflected at the temporal angle of the orbit, and which is brought into view when the pupil is fully inverted towards the inner canthus.

Should the tendon be found morbidly adherent, and incapable of retraction after its section, or should any changes of fascial, or other textures, be detected, it will be necessary to overcome these by freeing the former completely by dissection, or by dividing the latter with the scissars; so that all undue impediments to the restoration of the pupil to the visual axis of the orbit may be fairly removed.

Mr. Guthrie, in the continuation of his Report, already quoted, informs us that he has detected the existence of a sympathetic influence between the two abductors in divergent strabismus, similar to that so very frequently observed in the convergent affection; and that on dividing the abductor of the *apparently* sound eye, the pupil of the organ first subjected to operation has been in-

stantly restored to the proper central position that it ought to occupy.

I have myself also remarked the same circumstance, but strongly suspect that the second eye, *to all appearance sound,* is in fact implicated, though in a trifling degree This I am led to conjecture, because I have observed, in some instances, that a few days after operation the divergence has appeared to be transferred to the other organ; provided the eyes were submitted to the following test:—Having subdued the light in the apartment, so that it should not be offensive to the eye that had been the subject of operation, the patients were desired to close both eyelids gently, so that the orbital muscles might be allowed to fall into a state of complete repose; the upper palpebra of the eye presumed to be unaffected was then gently raised, when the pupil was perceived to be *everted* in a slight degree; while that of the other eye, which had not previously been completely restored to its natural position, was found, on reversing the experiment, to occupy the visual centre of the orbit. Now, it is in such case, I suspect, that dividing the abductor tendon in the second eye proves useful, and completes the cure; and from not being able to detect the evidence of this slight implication till some time after the separation of the tendon in the organ most affected, we may be led into the belief that we have completed the cure by operating in the second instance on a *sound* eye *.

* Vide Lancet, October 31, 1840: article by Mr. Elliot.

Treatment.—The treatment after this operation resembles, in every respect, that already described. Slight inflammation, and the secretion of a small portion of puriform discharge, is a more frequent result of the division of the external rectus than of that of its antagonist muscle. The globe of the eye is also more liable to swell and protrude for a day or two, and to feel uncomfortable and stiff to the patient; but both these inconveniences are easily subdued by warm anodyne fomentations.

Fig. 1.

Fig. 2.

Drawn from Nature on Stone by W. BAGG. Printed by C. Hullmandel.

APPENDIX.

Extracts from a Letter from Henry Gisborne, Esq. Surgeon, Derby, in reference to Case No. VII.

Derby, October 21, 1840.

DEAR SIR,

I am sorry it has not been in my power to reply to your kind note at an earlier period, as I was from home during the whole of last week. Our patient, Miss T——, I consider to be, in general appearance, much improved, though the strabismus at times is still very perceptible.

Her case always appeared to me to be an unfavourable one for operation, the squint being excessive, and of long duration—forty years at least. The sight of the affected eye, moreover, was very much impaired, the lens having been twice broken up for cataract. Miss T——, however, considers that her vision is improved, and that she possesses a greater power of viewing objects placed at her side. The motions of the eye are free, and nothing like protrusion of the

organ is perceptible. On looking stedfastly at any fixed point, the squint *is not perceptible;* but the moment that the general muscular action of the face is called into play, the eye involuntarily rolls somewhat inwards. I cannot but think that the external rectus will, by habitual practice of lateral vision, increase in its contractile power, and that her appearance will be still more improved.

Since you were in Derby I have seen a vast number of patients who have undergone the operation with very great success: others, *with no benefit at all.*

I trust you will, in your forthcoming volume, caution practitioners against operating for the sake of *numbers,* in lieu of the prospective advantage of their patients.

The operation is an excellent one, but I fear it will get into disrepute if proper cases are not selected. It strikes me, that the remote and proximate causes of strabismus should be known previous to operation. In advanced life I should consider the operation would be very likely to fail; since it is possible that one of the recti having been put upon the stretch, and elongated by the constant contraction of its opponent, would not possess sufficient tonic power to keep the eye straight, though the contracted rectus were divided.

If any further change should take place in Miss T——'s case, I shall be too happy to communicate with you. I am, Dear Sir,

Yours very faithfully,

HENRY GISBORNE.

Query.—*Is the portion of the retina on which the image of objects is depicted, and which corresponds to the natural visual axis of the eye, endowed originally with greater sensibility than the other parts of the retinal expansion, or is its apparent peculiarity in this respect the result of habit and constant use?*

This question is one that has frequently engaged the attention of physiologists.

"The portion of the retina," observes Mr. Walker*, "which corresponds with the axis of the eye, is usually regarded as being more sensible than the rest of the membranous expansion of the optic nerve. No doubt there is general sensibility over the whole of the retina, by which we perceive the outline of a great number of objects; but if we fix the eye upon any one object, or upon any particular part of an object, the image of each separate portion successively must be traced upon that part of the retina in the axis of the eye. Now, whether the superior sensibility and aptitude to convey impressions to the brain be inherent in this portion of the retina, *i. e.* an original property of the part, or only the result of habit and constant employment, has been a matter of conjecture." This question, however, now appears to be capable of a decided reply. The property is inherent in the particular part alluded to. When a patient presents him-

* Walker's Philosophy of the Eye, p. 199.

self who squints very much, we almost invariably find that his vision is obscure, and indeed, as has been already stated, in some cases, almost amaurotic. One obvious reason of this imperfection of vision is the image not being depicted on the most sensible portion of the retina; since, immediately on the eye-ball being liberated, and its axis being made to correspond with this portion of the retina, vision is improved, and becomes much clearer as soon as the eye recovers the first shock, and the temporary state of congestion, induced during the performance of the operation by the forcible efforts of the patient to close the eyelids. Were this portion of the retina not primitively endowed with superior visual sensibility, it would require some little time to educate it to the performance of its new function; but, on the contrary, it evinces in some degree its peculiar capacity from the first moment that it has the power of doing so, though it afterwards for several days improves by practice.

Observations on the Effects of dividing the Tendons of the various Orbital Muscles in Animals.

In order to aid me in deciding on the best mode of remedying certain untoward events that occasionally supervene after the performance of Dieffenbach's operation for the cure of strabismus, I undertook a series of experiments on animals for that purpose. The results of these inquiries,

though not so satisfactory as might be desired, still present facts of considerable practical importance, worthy of careful consideration.

In conducting the experiments to be presently detailed, I may state that I was favoured, on different occasions, with the assistance and judgment of Drs. Marshall Hall and Child, and of Messrs. Samwell and Farquhar, surgeons, as well as with the opinions of various non-professional friends, who, being totally ignorant of the nature of the investigation, and consequently unprejudiced in favour of any cherished theory, or anticipated results, were the more likely to take an unbiassed view of the phenomena that they witnessed, than we ourselves, who, it may be presumed, could scarcely avoid entertaining preconceived notions.

Before detailing the facts that presented themselves to our notice, it may be premised that great difficulty was experienced in performing the experiments with sufficient accuracy and care to insure the complete division of what was required; and, at the same time, to confine the operations precisely within that limit.

All experiments of the operative kind on the orbital muscles of animals, in order to ascertain their respective functions, must, on several accounts, prove more or less unsatisfactory. The anatomical adaptation of the powers which move the eyeball in brutes, differs materially from that observed in the human species.

In animals there exist certain additional muscles and appendages to the eye, which

modify the operations of the simple mechanism possessed by them in common with man. Thus, animals are furnished with a muscle denied to man, the *suspensorius*, by which they are enabled to retract the eye in a most remarkable and powerful manner.

The principal object of this muscle seems to be to assist in retaining the eyeball *in situ*, and to obviate any inconvenience, or bad consequences, that might result from the long-continued dependent position of the head, during the time that the animal is feeding, which, in *Ruminants*, engages so considerable a portion of the twenty-four hours.

In this class of animals, therefore, we find the suspensorius muscle not only powerful, but very large and funnel-shaped, so as to completely and uninterruptedly embrace the posterior half of the eyeball, and thus most effectually to accomplish this apparently important end. In *carnivorous* animals, whose time is not so much occupied in feeding, and whose heads, therefore, are not so constantly in a depending position, the suspensorius muscle is not so powerful or comprehensive. On the contrary, it is divided into distinct parts, forming, in fact, four independent fleshy slips, which have a common origin, but are inserted into the sclerotis by separate tendons reaching to the greatest transverse diameter of the eyeball, and passing between the attachments of the four principal recti muscles. The oblique muscles also, in ruminating and carnivorous animals, differ from each other in many respects. In the latter class, and in man, the

superior oblique becomes tendinous immediately before it reaches the pulley affixed to the orbital angle of the frontal bone, and continues its tendinous form, from this point of reflexion, to that of insertion into the sclerotic coat: whereas, in ruminants, the reflected portion of this muscle forms a second fleshy belly of considerable thickness and power, which again becomes tendinous before its final insertion. The part of the eye-ball into which this muscle is inserted does not precisely correspond with the same portion in man; the insertion of the tendon being a little nearer to the cornea in animals. The *inferior* oblique likewise, in animals, is a much stronger, more fleshy, and abrupt muscle, than it is in man, in whom its insertion is much more extensive, and effected by means of a stronger and more spreading tendon.

When any attempt is made to injure the eye of an animal, the suspensorius, or more properly the *retrahens* muscle, immediately draws the eye-ball back into the orbit; and, in doing so, still further protects the organ, by causing the immediate and forcible advance of the membrana nictitans, which unfolds and spreads itself like a curtain over the fore part of the eye.

In experimenting on the internal rectus and oblique muscles in particular, this membrane is a source of great difficulty and embarrassment to the operator, as it not only comes constantly in the way of his instruments, but prevents the observer, after the desired end may have been

accomplished, from ascertaining the precise direction in which the pupil is drawn, when the eyeball performs any rapid or involuntary movement, such as may result from slightly irritating the cornea with a feather, or the like.

In all the movements of the eye, indeed, that are not voluntary on the part of the animal, difficulty is experienced in making allowance for the influence of this suspensorius, as any portion of it appears to be capable of being called into play, to the exclusion of the rest of the muscle, especially in animals of the carnivorous tribe, in which, as just explained, it is divided into four distinct auxiliary recti muscles. Thus, if the adductor draw the pupil towards the nasal canthus of the orbit, and the inner portion of the suspensorius or retrahens co-operate with it, the effect is much heightened by the inner portion of the eyeball being at the same time drawn back towards the origin of this auxiliary muscle; and the same is the case when any of the other three recti are forced into involuntary action. Could a series of experiments be performed on any of the ape tribe, the orbital muscles of which class of animals resemble in every particular those of the human species, we might possibly arrive at better and more satisfactory conclusions. But even then we should have to contend with another difficulty, that equally opposes our inquiries when experimenting on a class of animals inferior to this, viz. the want of that intelligence which distinguishes reasoning beings.

We cannot, of course, when a muscle is divided in a brute creature, estimate the result in all its bearings, as in man, by requiring the animal to move the eye in such directions as would aid our judgment, and satisfy us that specific results have been attained, and certain objects accomplished. On the contrary, the only conclusions we can arrive at must be deduced from a comparison of the movements of the two eyes, when, by stratagem, we can excite the natural contractions of certain muscles in the organ that has not been the subject of operation. If, on inducing special movements in the sound eye, we find that those of the other organ do not correspond, we may fairly conclude, if they were previously complete, that the power of producing them has been destroyed.

Notwithstanding all these obstacles, however, a few plain and incontrovertible facts do present themselves, which are of sufficient practical utility to merit careful consideration.

The first experiments that I shall relate were instituted with a view to ascertain the results of dividing the several recti muscles.

Exp. I.—*Division of the Internal Rectus.*

The tendon of the adductor of the left eye, of a middle-sized half-bred spaniel dog, was carefully separated from its attachment to the sclerotis. The pupil was instantly directed permanently towards the outer angle of the orbit; and to such an extent that, next day, fully one-third of the

cornea was concealed from view. The animal appeared to be wholly incapable of disengaging the pupil from this situation; nor did he acquire the power of doing so in the slightest degree afterwards.

Exp. II.—*Division of the External Rectus of the same Eye.**

In the course of a week from the performance of the above operation, the *external* rectus of the same eye was divided, but without producing any sensible alteration in the position of the eyeball; the pupil still continued to be everted, and partially concealed in the temporal angle of the orbit.

From these facts we may conclude, either that the muscle had not formed a re-union with the sclerotic coat, or that, the eyeball having been so long unremittingly turned outwards, the re-union was established too far posterior to the original insertion to enable the muscle to invert the pupil again.

Exp. III.—*Division of the External Rectus Muscle alone.*

The abductor of the left eye of another dog, similar in size to the last, being carefully divided,

* This experiment, though performed a week aftewards, is detailed here, as being connected with the former one.

the pupil was permanently turned inwards towards the nasal canthus of the orbit, but not quite in so great a degree, as in the first experiment it was turned outwards. Nor did the animal, in this instance, apparently possess any power to dislodge it from its unnatural situation. This we ascertained, in both experiments, by holding its head in a particular position, and then calling the attention of the animal to the opposite direction. On such occasions the intact eye alone obeyed the summons of the will; the other did not move in unison with it.

From the three foregoing experiments, which were afterwards several times repeated, and farther verified in the course of operating on other animals, we may infer—

That, when all the orbital muscles are in a *sound* and *healthy* condition, if we divide either the adductor or abductor, the natural tendency of the antagonist muscle is to contract in the fullest degree of which it is capable; and that, in doing so, it will produce a deformity of the eye similar to that which characterizes ordinary internal or external strabismus;* with this

* If this result be the general law when the orbital muscles are divided, while in a healthy condition, then the second argument adduced, page 23 of these observations, to explain the reason why the pupil does not usually turn outwards after the operation for convergent strabismus, falls to the ground. Indeed this argument was very satisfactorily negatived some time ago by Mr. Hocken, (vide Medical Gazette, Nov. 14,) and would have been cancelled in the present volume, had not that sheet and the succeeding one been struck off before these experiments were completed, or Mr. H.'s critique appeared.

difference, that the movements of the eyeball in the direction of the cut muscle will be wholly destroyed. When, however, we divide the adductor in the human eye, for the purpose of remedying strabismus, we very rarely find that the pupil is drawn outwards beyond the visual axis of the orbit. Hence we may conclude, that, under such circumstances, the eyeball is either prevented from turning outwards by some retaining adventitious cause, independent of the contracted adductor, which, after its section, no longer offers any opposition, or that the external rectus has been previously partially paralysed, as supposed by Mr. C. Guthrie (vide his Report). These facts, moreover, point out the propriety of not only satisfactorily ascertaining that the eye is affected with *confirmed* strabismus previous to operating, but, at the same time, warn us of the troublesome, if not unfortunate, consequences that may possibly result from immediately dividing the adductor tendon in the second eye, *when not in any way implicated,* as proposed and practised by Mr. Elliot, of Carlisle, should the section of the tendon of the faulty organ not prove *instantly* and *completely* successful.*

Another inference to be deduced from the foregoing fact is, that the oblique muscles take very little part in the lateral movements of the eyes.

* Vide Lancet, October 31, 1840.

When the internal rectus was divided, the obliques did not enable the animal to approximate the pupil at all to the nasal canthus of the orbit; neither did they, on the other hand, contribute the power of everting the pupil, when the external rectus was divided, unless in a very trifling degree; since it will be observed, by reference to the third experiment, that the pupil was not proportionally so much *inverted* when the external rectus was detached, as it was *everted* on the division of the internal muscle. This difference in the degree of displacement of the pupil may have been attributable to the combined action of the two obliques, if their actions be in any way calculated to aid that of the external rectus, as was supposed by Albinus, and is still maintained by Sir Charles Bell, Dr. Marshall Hall, and others. The power, therefore, that many patients possess of turning the pupils slightly inwards after the adductor muscle is divided, we may presume to be dependent much more on the acquired influence of the inner fibres of the superior and inferior recti, than on the action of the oblique muscles. Hence, also, another argument in proof of the doctrine, that division of either of these latter muscles can never be requisite in the cure of convergent strabismus.

But a practical question of much importance suggests itself for our consideration in reflecting on the foregoing facts, viz. When the pupil is very much everted on dividing the internal rectus—so much so, I mean, that we are satisfied time will

not rectify the position the eye has assumed—ought we to wait, before cutting the tendon of the abductor, until re-union shall have taken place between that of its antagonist and the sclerotis, or ought we at once to perform this second operation?

When such an event takes place, *i. e.* when the pupil is everted in a remarkable degree, I apprehend that the case is one in which the strabismus had been primitively produced by *spasm* of the inner rectus; and that the external muscle, being in a healthy condition, was capable of its fullest degree of contraction. Were we to wait in such case, it is possible that the adductor might form a re-union too far back to be able to restore the pupil to the axis of the orbit, when the abductor tendon should be afterwards separated. If, on the other hand, we do not wait, we have seen that the eye will, in all probability, not be restored to its normal position, while both muscles are equally incapable of action, but that it will retain the position in which it was placed by the first operation. This *permanent* state of eversion, however, is a circumstance that, it would seem, does not occur in the human eye under the circumstances we are considering. However much the external rectus may contract after the adductor has been cut across, in a *strabismal* eye, the patient always possesses the power, when the eye is used *in conjunction with its fellow*, of bringing it to the central point between the inner and outer angle of the orbit, although at such moments the axes

of the two eyes do not correspond, and vision is consequently double. If, however, a case were to present itself in which the pupil should be permanently turned outwards after the division of the adductor tendon, and the patient did not possess the power of removing it from this position, it occurs to me that we should gain nothing by waiting until the inner tendon was reunited, and that it would be better to divide the outer muscle at once. It is possible in such case, were the eye liberated, that the superior and inferior muscles might rectify the morbid position of the pupil. A case parallel to that just supposed, it will presently be shewn, has actually occurred with regard to the superior rectus in the human eye.

From the foregoing experiments we should naturally expect that similar phenomena would attend the division of the superior and inferior recti; but such is not the case.

Exp. IV.—*Division of the Inferior Rectus.*

In this instance the tendon of the inferior rectus was separated with great care:* the animal lost completely all power of directing the pupil downwards, when that of the other eye was depressed;

* These dogs were in general afterwards killed, within an hour or two, and care was always taken to ascertain that the proposed object had been accomplished.

but it was not drawn upwards, as was expected, by the action of the superior rectus. Three days afterwards, however, it was found to be displaced in this direction, the upper third of the cornea being concealed under the superior palpebra, which situation it continued to occupy.

Exp. V.—*Division of the Superior Rectus.*

The superior rectus of the left eye of a middle-sized dog was separated from its insertion; the position of the pupil was not altered, although it appeared that the animal could not direct the eye upwards.

Exp. VI.—*Division of the Inferior, Internal, and Superior Recti.*

This experiment, as will be immediately shewn, was performed for a special purpose.

The inferior rectus was first detached, then the adductor, and finally the superior muscle. The pupil at first preserved its natural central position, but in the course of two days afterwards was found to be directed outwards, and very slightly upwards.

My object in performing this experiment was to ascertain whether, when the internal rectus has been divided to remedy strabismus, and the pupil is drawn upwards under the superior palpebra in

consequence of the deformity having arisen from paralysis of the inferior rectus, any benefit would be derived from dividing the superior muscle. From the result of the experiment, and the experience of two cases of this description which have been already (pp. 17 & 19) related, I am of opinion that the operation would be useful *after the adductor tendon has become re-united to the eyeball.*

Exp. VII.—*Division of all the Straight Muscles.*

In this experiment all the straight muscles were detached: the pupil remained fixed in the visual axis of the orbit. When irritated, the eyeball was retracted, and the membrana nictitans was suddenly spread over the fore part of the eye at the same moment, so that it was quite impossible to decide what influence the oblique muscles exerted, or whether they produced any special movement at all. It was clear, however, that they neither drew the eye towards the outer nor the inner angle of the orbit. Hence I am disposed to imagine, as already stated, that when both of these muscles contract together, they tend to steady the eyeball in the visual axis of the orbit, and contribute to modify the focus of the eye by compressing the sphere. They are, in such case, opponents, though in a slight degree, of the external rectus.

Exp. VIII.—*Division of the Superior Oblique and Internal Rectus Muscles.*

The greatest difficulty was experienced in performing this operation satisfactorily, in consequence of the retraction of the eyeball, and the protrusion of the membrana nictitans. A sharp-pointed bistoury was introduced at a right angle to the tendon, and about midway between the trochlea affixed to the frontal bone, and the insertion of the muscle into the sclerotis. The instrument was pushed sufficiently deep into the orbit to secure the cutting of the tendon on its being withdrawn with the point in contact with the roof of the orbit. There could, therefore, be no doubt that the tendon was divided. No apparent change occurred in the position of the pupil; nor could we perceive that the movements of the eyeball were in any way modified, or destroyed, by the operation.

The insertion of the internal rectus of the same eye was next separated from the sclerotis, and instantly the eyeball protruded *considerably*, and the pupil—dilated in a most extraordinary manner*—

* Slight temporary dilatation of the pupil often intervenes in the ordinary operation for strabismus, on dividing the internal rectus, especially in those cases in which the eyeball becomes somewhat more prominent immediately after the operation. But, when, in an animal, either of the oblique muscles is cut across, the enlargement of the pupil is very considerable. The iris contracts into a fine circular band, not above half a line or

was drawn diagonally outwards and upwards, as if by the equal co-operation of the outer fibres of the superior rectus, and the upper fibres of the external, or abducens, muscle. The eyeball afterwards retained this position, and, when the muscles were sympathetically irritated to involuntary contraction, by gently touching the cornea, was always retracted by the action of the retrahens. On such occasions, the upper and outer portion of the sphere appeared to be the part most retracted; the lower and inner portion being at the same moment made to advance obliquely, and project in a remarkable manner.

Exp. IX.—*Division of the Internal Rectus and Superior Oblique Muscles.*

In the ninth experiment the foregoing operations were reversed on another dog: the section of the internal rectus was first performed, then that of the superior oblique muscle. The results were similar to those just related. The eyeball was directed outwards and upwards; its anterior in-

a line in breadth, and the eye presents an appearance very similar to that produced when the animal is poisoned with prussic acid. We should naturally imagine, as the pupil dilates when the eyeball is compressed, and contracts again when the pressure is withdrawn, that liberating the sphere, by cutting a portion of its attachments, would give rise to contraction; but the contrary is the invariable result. It may be presumed, then, that when the eye protrudes, the remaining recti muscles, being stretched, compress the sides of the globe.

ferior surface was brought into view, and considerable protrusion took place, accompanied with remarkable dilatation of the pupil. When the internal rectus alone was divided in this experiment, as in No. 1, the pupil was turned directly outwards; but, when the superior oblique was cut across, its direction was found to be outwards and upwards. This diagonal direction of the pupil, then, in the two last experiments, although such as might be presumed would be produced by the equal co-operation of the external and superior recti muscles, I am inclined to attribute, in a great measure, to the uncounteracted action of the inferior oblique, since it was exactly what might have been anticipated from the direction of the fibres of this muscle, and did not become *diagonal* until the section of the superior oblique had been performed. Be this as it may, the other result, viz. great projection of the lower portion of the eyeball, so that the anterior part of its under surface was brought into view on slightly depressing the lower eyelid, could be attributed to no other cause than the contraction of this muscle when unopposed by the trochlear.

Exp. X. and XI.—*Division of the Inferior Oblique and Internal Rectus Muscles.*

These experiments were conducted in a similar manner to the two last related, and the section of the former muscle, the inferior oblique, was accom-

plished on the same principle as had been that of the superior oblique; the bistoury being withdrawn with its point in contact with the floor of the orbit. The results which succeeded were very similar to those we had already witnessed. The eyeball protruded as soon as the adductor was cut across, but not before; neither did it project in so great a degree as in the former experiments. The pupil was directed outwards, but not upwards; and in this situation it remained immoveably fixed.

Most of the foregoing experiments I have repeated several times, and uniformly with the same results; the degree in which they manifest themselves, however, being various in different animals.

On one occasion, when assisted by Mr. Samwell, on dividing the superior oblique, the pupil was drawn so forcibly towards the outer canthus by the action of the external and superior recti muscles, that, had it not apparently been for the restraining power exerted by the inferior rectus on the lower portion of the eyeball, it would have wholly disappeared.

What, then, are the functions of the superior oblique muscles? So far as may be inferred from the foregoing experiments, very little of a conclusive nature can be deduced.

It certainly appears somewhat paradoxical, and irreconcileable with a first view of the subject, that dividing one of two muscular powers, which both

tend, though perhaps in different degrees, to bring the eyeball forwards in the orbit, should be a means of causing it to advance still more, even to protrusion; yet such would appear to be the fact. If we reflect on the course and insertions of these two muscles (vide Pl. X. Figs. 1 & 2),* we shall perceive that, when they act singly, it is probable they antagonize each other in the *semi-rotatory* movements of the eyeball; and that when they contract at the same time, they will co-operate in drawing the eyeball forwards in the orbit, but *without causing it to revolve in any direction.* On the contrary, they will steady it; and, as the origin of both of these muscles is from the nasal side of the orbit, they will fix the globe of the eye in the visual axis when we look steadfastly at an object placed immediately before us, and at the distance from the eye at which we can see it the most distinctly; *i.e.* at the true focus of the organ—this being the position in which the exertion of a steadying power is of the most importance, and that which is the most frequently exercised of any. If, moreover, the focus of the eye be ever changed, so as to suit it to the various distances at which we survey objects, these muscles, it appears to me, may be very powerful agents in accomplish-

* It is presumed that the reader is sufficiently conversant with the anatomy of the orbital muscles not to require the more special reference to those named, that might have been given by lettering the engravings.

ing this purpose, by compressing the central portion of the sphere slightly between them, and against the cushion of fat which lines the nasal surface of the orbit; thus not only increasing the distance between the cornea and that portion of the retina on which the image is depicted, but also rendering the cornea itself more convex. The importance of steadying the eye, under particular circumstances, against any inadvertent contraction of the recti, and of accommodating its focus to view objects at various distances, is too obvious to need any comment; and I think we shall, on reflection, be inclined to admit that the same end could not be so efficiently attained by any combination of agency on the part of the recti muscles. When the trochlear muscle contracts, and the inferior oblique is relaxed, it appears to me that the effect will be to slightly rotate the eyeball downwards and inwards; and that when the lower muscle contracts, the upper one being at the same time relaxed, the effect will be to cause the eyeball to slightly revolve inwards, *i. e.* towards the nasal canthus, and upwards.

But we have seen that there was reason to believe that the inferior oblique aided the external rectus—a view that was taken of its actions by Albinus, and is still maintained by Sir Charles Bell, Dr. Marshall Hall, and others. Certainly, if we consider the direction of its fibres, and the extreme point of their expanded insertion, reaching nearly to the optic nerve (vide Pl. X.

Fig. 1*), we can scarcely avoid arriving at this conclusion also—viz. that when left free to contract, as it especially is, if the tendon of its antagonist be divided, it will direct the pupil outwards and upwards, and thus assist the external rectus. But not so the superior oblique; at least certainly not in so great a degree. Its insertion, which is by a round tendon, does not usually extend more than two lines beyond the central diameter of the sphere†; neither does it, in so great a degree, transversely embrace its circumference. To me it appears probable that this muscle, *when both obliques are entire,* can only assist the *internal* rectus, while the inferior one may aid the *external* muscle in certain compound movements of the eye, the nature of which we at present know little or nothing about.

But there is a practical inference to be deduced from the foregoing facts, of considerable importance.

* The preparation from which this drawing was taken was dissected with very great care, and is delineated with the most faithful accuracy.

† In most works on anatomy we are informed that the insertion of the trochlearis does not extend beyond the great diameter of the eye. But this, it would appear, is not correct. I have of late dissected a number of eyes for the purpose of ascertaining this fact, and have, in every instance, found the insertion to be posterior to the greatest diameter of the eyeball. In the preparation from which the annexed engraving was delineated, and still in my possession, the ultimate fibres of the tendon were, by careful measurement, ascertained to be inserted more than three-eighths of an inch posterior to the central diameter of the sphere.

If the eyeball be protruded in the manner we have seen it may be, when either of the oblique muscles is divided in animals furnished with a suspensorius or retracting muscle, how much more might we fear it would be so, were the same operation practised on man, to whom this muscle is denied.

Presuming this extension of the operation to have been attempted with impunity, it appears to me unnecessary to offer any comment on the propriety of farther inquiry before it be repeated.

The following observations on the functions of the orbital muscles, extracted from Mr. Walker's Philosophy of the Eye, though not in exact accordance with the views set forth in the foregoing pages, are yet, on the whole, so much confirmed by the results obtained in the series of experiments just related, that I shall make no apology for availing myself of them in concluding the present volume.

Observations on the Function of the Oblique Muscles. Extracted from Mr. Walker's Philosophy of the Eye.

The action of the superior oblique or trochlearis, as it is called, from the trochlea or pulley through which it passes, is to turn the axis of the

eye, that is to say the pupil, directly inwards. This muscle, although arising from the back part of the orbit, must be regarded as having its fixed point at the pulley, which is placed in front of the orbit on the inner side next the nose. Now, by exposing the back part of the orbit, and by pulling at the extremity of the trochlearis muscle, it is demonstrable that the eyeball is turned round somewhat upon its axis, that the insertion of the muscle is brought towards the pulley, and that the front of the eye is turned inwards. This is, undoubtedly, the action of the trochlearis muscle, as I have ascertained by repeated experiments upon the muscles within the orbit. Such opposite opinions are recorded on this point that it is necessary to examine for one's self. Thus Albinus, Sir Charles Bell, and many others, describe it as turning the eye outwards and downwards—a view which I had myself taken before making the experiment. They presume that the muscle is inserted *behind the centre of motion of the eyeball*, and so it generally is, to the extent of from one to two lines (vide Pl. X. Fig. 1), and that when it acts it pulls the back of the eye forwards and upwards to the pulley, and so turns the front of the eye in the opposite direction. It is, however, *not inserted behind, but directly over the centre of the eye, just under the tendinous extremity of the superior straight muscle*, and passing down a little way towards the outer straight muscle. Meckel, Cloquet, and others, state that it acts in the direction I have men-

tioned, viz. inwards; and those who will examine for themselves will find this to be the true action of that muscle. The action of the inferior oblique muscle rotates the eyeball in precisely the opposite direction to that of the superior, and likewise turns it inwards; so that if the eye be rotated upwards by the trochlearis, it will be rotated downwards by this muscle, which is therefore the antagonist of the former.* Its situation and direction, as well as actual experiment, prove this, for it has its fixed point in front of the orbit, just at the inner angle of the eye, whence it proceeds downwards near the edge of the orbit, passes outside of the inferior straight muscle, and is inserted into the globe just beneath the extremity of the external straight muscle. The grand error, which has prevented us from arriving at a proper knowledge of the actions of the muscles of the eyeball, appears to consist in regarding those actions singly; or in classing the muscles into straight and oblique, and presuming that the one class are antagonists to the other, and that those of each class act together in that capacity. Nothing can be more unfounded than such a supposition. No view can be better calculated to keep us in ignorance as to their real uses. It is certainly necessary to possess an accurate knowledge of the actions of the separate muscles, before we can properly understand them in a state of combination. And how is this

* The terms "upwards and downwards" here, are by no means clear.

knowledge to be obtained? What muscles act together, and what have a separate or antagonist action? And what are the laws by which these actions are combined, separated, and regulated? These are questions which can only be satisfactorily answered by a reference to the nerves, the agents that regulate the actions of the muscles.

Now, the muscles without the nerves would be utterly powerless: these latter direct, combine, and regulate the actions of the moving powers; and if any injury or disease happen to the nerves, the muscles to which they are distributed will be paralysed. The nerves in the orbit are very numerous, complicated, and difficult to understand. The best way to become acquainted with their functions is to observe to what parts they are sent, and then to ascertain the uses of those parts. Thus we notice that three different nerves pass to the muscles of the eyeball. The uses of these muscles being to effect the various movements of the eye, therefore the nerves which stimulate these muscles are called motor nerves. These three motor nerves of the eye are variously denominated, sometimes in the numerical order in which they come off from the brain, as the third, the fourth, and the sixth.

The third is likewise named the motor oculi, from its being the principal moving power of the eye, distributed to all the muscles of the eyeball except two, and, in addition, to one of the muscles of the eyelid and to the iris, so that it is justly regarded as the most powerful and im-

portant muscular nerve of the eye—a conclusion, the correctness of which cannot be doubted, when we reflect on the number of muscles to which it is distributed, and the extensive combinations which it directs. The fourth nerve is also called the trochlearis, because it goes exclusively to the muscle which passes through the pulley. The sixth is sometimes called the external motor nerve, because it goes only to the external straight muscle of the globe.

Considering that the nerves are the directing agents by whose powers the muscles are set in motion, we seem naturally led to the conclusion that where there are separate nerves there must also be different actions. And when we come to notice the actions of the muscles which are directed by the third nerve, we cannot help observing that, to a considerable extent, there is an agreement between them. These muscles are employed when we direct the eyes straight-forwards, with the modifications inwards, upwards, and downwards; and these form one grand class of movements, in which both eyes always act in concert. They are the joint production of the superior, the internal, and the inferior straight muscles. In addition to the power of looking straight before us, we have also the ability of directing the eyes laterally, and this cannot be effected by the muscles we have just enumerated. This being an opposite action requires a different moving power, and a separate nervous supply. Accordingly we find a muscle, the external

straight muscle, placed along the outside of the orbit, attached to the outer side of the globe of the eye, and capable of acting as an antagonist to the muscles supplied by the third nerve, whose action we have said is in the opposite direction. For this purpose it is supplied by a separate nerve, the sixth.

An examination of the structure and arrangement of this muscle will shew us that it is much stronger than any of the muscles which are supplied by the third nerve; for, first, it is much longer, owing to the form of the orbit and the position of the eye; secondly, it has a double origin, and, therefore, two fixed points of action—circumstances which must render it a much stronger and more powerful muscle, and give to it a greater latitude of motion; and finally, we may presume that the nerve being exclusively distributed to this muscle, must tend to centralize its influence. The external straight muscle, indeed, may almost be regarded as a double muscle. Having two origins, it is clear that each of these will be capable of turning the eye in a direction somewhat different from the joint action of both. Thus the action of both will be to turn the eye directly outwards, whereas their separate actions will tend to direct it upwards or downwards at the same time.

Thus we have accounted for the actions of all the muscles of the globe, except that of the trochlearis—that extraordinary muscle, which seems to stand aloof from the others; not like either of the

rest, but partaking of the common nature of the straight muscles and that of the inferior oblique, compounded of both. Passing with the muscles supplied by the third nerve, and yet having a nerve which is separate and independent, it stands conspicuous and alone, holding the balance, as it were, between the antagonist powers over which it is placed, and apparently capable of acting independently of either. Now, it is evident, from all these circumstances—the extraordinary course it takes, its peculiarity of arrangement, the great power it seems capable of exercising, and its separate nervous supply—that the trochlearis muscle is intended to act a different and independent part to that of any of the others.

We have seen that there is ample provision for the movements of the eyeball, in every direction in which we can conceive them to take place. We have seen that the muscles supplied by the third nerve are capable of performing all the movements connected with the straight-forward direction of the eye, whether upwards, downwards, or inwards. We have seen, also, that there is an antagonist muscle placed on the outside of the globe, that muscle having the power of turning the eye outwards, being the only one which has such a power, and having a special nerve bestowed upon it for this particular purpose. What, then, can be the use of this additional muscle, the trochlearis? This will be seen as we proceed.

A very remarkable circumstance, next to be considered, is, that the muscles of the third nerve

invariably act together in each eye, so as to direct both simultaneously to those objects which are placed straight before us; but when we come to direct the eyes to any object situated to the right or left side of us, we turn one eye, that nearest the object, outwards, by means of the external straight muscle; whilst the other eye is turned directly inwards, in order that it also may be directed to the same object. And this inward direction of one eye, when the other is turned outwards, is constant and invariable. Indeed, under no circumstances, can we, at the same moment, direct both eyes outwardly. Now, as the muscles of the third nerve are concerned in those actions in which the two eyes correspond, it is manifest that we must have a separate muscle and nerve to direct the one eye inwards with the outward action of the other, because they no longer correspond; so that we have a nerve for the muscles which direct the corresponding motions of the two eyes, which is the third nerve, and we have another nerve for the muscle which turns the eye outwards, where there is no such correspondence in the action of the muscles of the other eye, and that nerve is the sixth. Now, if the external straight muscle were to act in both eyes together, then one eye would be directed towards the object desired to be seen, and the other would be turned away from it; and hence the necessity for another nerve and another muscle to direct one eye inward with the outward direction of the opposite eye—a necessity met by the troch-

learis nerve and muscle. That this is a matter of great importance cannot reasonably be doubted.

The eyes are so intimately connected, and act so completely together, that they cannot be properly compared to organs which are capable of acting independently of each other, such as the hands. The eyes ought, indeed, rather to be regarded as one, a double organ. So much attention, and so much effort, have been displayed in conjoining their actions, that such conjunction is evidently of first-rate importance. The union of the two optic nerves—a circumstance unparalleled, and which doubtless has reference to this end, together with the utter impossibility of directing one eye to one object, and the other to another, as well as the general correspondence of the two eyes in infants and blind persons, all lead to this conclusion.

And this affords us a reason why there should be such a complexity of muscles, and such a multiplicity of nerves. How different is the action of the eyelids from that of the eyeball! Thus, we can voluntarily shut or open either eyelid separately; but over the eyeball we have no such control, since it is impossible for us to direct one eye to an object, without the other accompanying it.

The power is not given to us of causing the muscles to act indifferently, in either eye, with their corresponding or antagonist muscles; and, therefore, those of the third pair of nerves can never act with their antagonists, those of the sixth

pair, the external straight muscles: and in the case of one eye being turned outwards, if the other were to be turned inwards by the internal straight muscle, it must be followed by the action of the same muscle in the other eye, and both would correspond, when such correspondence would be improper. Hence we perceive the necessity for a superadded muscle and nerve—the trochlearis—to act in turning the eye inwards, when the other is directed outwards.*

Now, if the eyes had merely possessed the power of looking straight forwards, and had not been endowed with that of directing themselves laterally, there would have been no occasion for any muscles, except those which are used in looking straight forwards; and then there would have been none of that complexity of either muscles or nerves; one nerve, and one class of muscles, would alone have been necessary. But by supplying us with a muscle to turn the eye outwards, and by farther giving us the power, at the same time, of turning the opposite eye inwards, in order that both may be directed to the same object, a most intricate piece of mechanism has been produced, two additional muscles and two additional nerves have been added—one muscle and one nerve to effect the outward direction of one eye, and one nerve and one muscle to associate with it the inward direction of the opposite. This view seems

* The addition of the inferior oblique seems necessary to antagonise the trochlearis, and is therefore placed under the control of the third nerve.

to offer a key to the actions of the muscles of the eyeball. It elucidates the functions of those muscles, and their nerves, in a manner which appears more satisfactory and complete than any other with which I am acquainted. The ingenious observations of my colleague, Mr. Hunt,* opened the way to it; they furnished the first link of the chain of reasoning. I have pursued the subject, and I do not perceive that any one, who regards the action of the trochlearis as being that which I have described it, as turning the eye inwards, can dissent from the explanation above given of the functions of the motor nerves and muscles of the eyeball. It is one of those points, however, that have puzzled physiologists from the very earliest times; and, therefore, before this is admitted to be the true explanation of the matter, it must be further sifted, and examined in all its bearings. In the meantime, it is offered as a suggestion worthy of the attention of physiologists, and one which I conceive will bear investigation.

It is impossible, otherwise than as just explained, to conceive the necessity, or use, of the trochlearis muscle. Mr. Lawrence has remarked, "the precise use of these oblique muscles is not very obvious, as the recti seem capable of performing every sort of movement which the globe is capable of." And certainly, if we had been provided with one eye only, or been destitute of the lateral direction of the eyes, before noticed, it would be very

* Vide London Medical Gazette, vol. xix. p. 20.

puzzling to perceive the use of the trochlearis muscle; but to imagine that this muscle should have been formed, and a separate nerve given to it, for the trifling purpose of turning the eye outwards and downwards, when this end could be effected by the muscles previously provided, and with no other intention, appears to be so futile a proposition, that no one, it may be supposed, could seriously maintain it. The physiology of these muscles has never hitherto been properly understood; and, with respect to the nerves, we can scarcely consider that a rational opinion has been offered, if we except that of Sir C. Bell, who supposes the fourth to be an involuntary nerve, and that the third and sixth nerves are voluntary; but he offers no reason why there should be two voluntary nerves, or why one of them should be distributed to one muscle only, or why the fourth should also be distributed to one muscle only, when he supposes that both oblique muscles are involuntary.

Mr. B. Cooper, in his "Lectures on Anatomy," speaking of the circumstance of the sixth nerve supplying only one muscle, admits that "no clear physiological theory has been formed upon this anatomical fact." To suppose, indeed, that two separate nerves should go exclusively each to a separate muscle, one to turn the eye outwards and the other outwards and downwards, appears absolute nonsense, and could only be entertained in the entire absence of any thing like a plausible explanation of the real facts of

the case. Thus, then, with regard to the muscles of the eyeball, as far as our present views extend, it appears that their actions are regulated by the nerves which are distributed to them; that where a set of muscles is influenced by one single nerve, there is there a common or joint series of actions; that when there is a separate nerve going to a muscle which acts in an opposite direction to the others, as the external straight muscle, it is to supply it with an opposite and antagonist power; and, lastly, that when there is a nerve and a muscle superadded to these, as the trochlearis, it has a special and independent action, and, in the present instance, serves to direct the internal movements of one eye with the opposite motions of the other, so as to direct both, when viewing an object, laterally to the same point.

THE END.

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